EXHIBIT I

Exhibit F10-354D
Invalidity of U.S. Patent No. 9,154,354 Patent based on Peeters

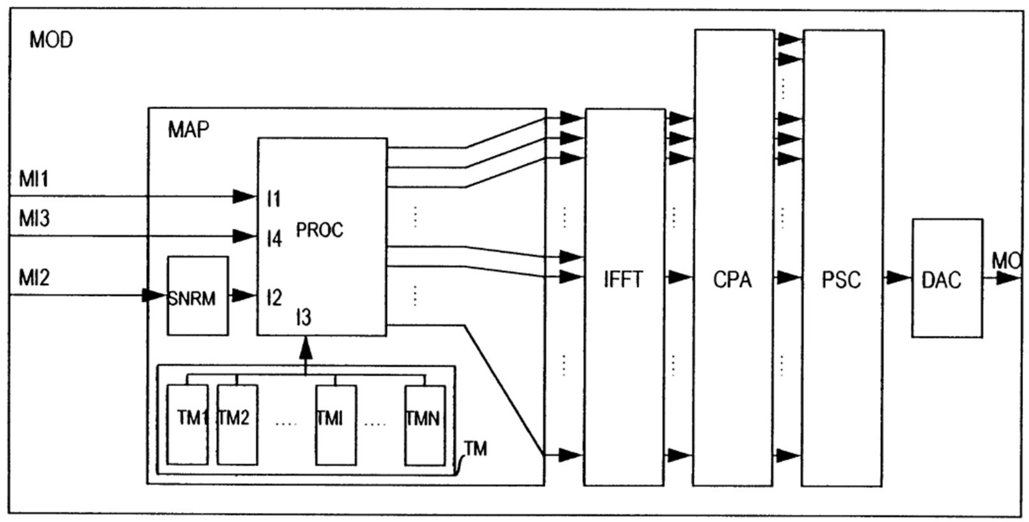
European Patent Application EP 0753948A1 to Johan Peeters, Paul Marie Pierre Spruyt, and Jean-Francois Van Kerckhove ("Peeters"), titled "Capacity Allocation for OFDM," published on January 15, 1997. Peeters is therefore prior art to U.S. Patent No. 9,154,354 ("the '354 Patent") under at least 35 U.S.C. § 102(a) and (b).

This invalidity claim chart is based in whole or in part on Nokia's present understanding of the asserted claims, its current construction of the claims, and/or TQ Delta's apparent construction of the claims in its current infringement contentions. Nokia is not adopting TQ Delta's apparent claim construction, nor admitting to the accuracy of any particular claim construction. To the extent that TQ Delta's apparent claim construction or applications thereof are reflected in this invalidity claim chart, nothing herein should be construed as an admission that Nokia agrees with TQ Delta's apparent claim construction or TQ Delta's application of that claim construction in TQ Delta's current infringement contentions.

The use of this reference or combinations of references as invalidating prior art under 35 U.S.C. §§ 102 and/or 103 may be based on TQ Delta's allegations of infringement. Nokia does not necessarily agree with the interpretations set forth in TQ Delta's infringement contentions and thus this invalidity claim chart is not an admission that the accused products meet any particular claim element or infringe the asserted claim. In addition, nothing in this invalidity claim chart should be interpreted as a position about whether any portion of the asserted claim is limiting or not. Further, by submitting this invalidity claim chart, Nokia does not waive and hereby expressly reserves its right to raise other invalidity defenses, including but not limited to defenses under 35 U.S.C. §§ 101 and/or 112.

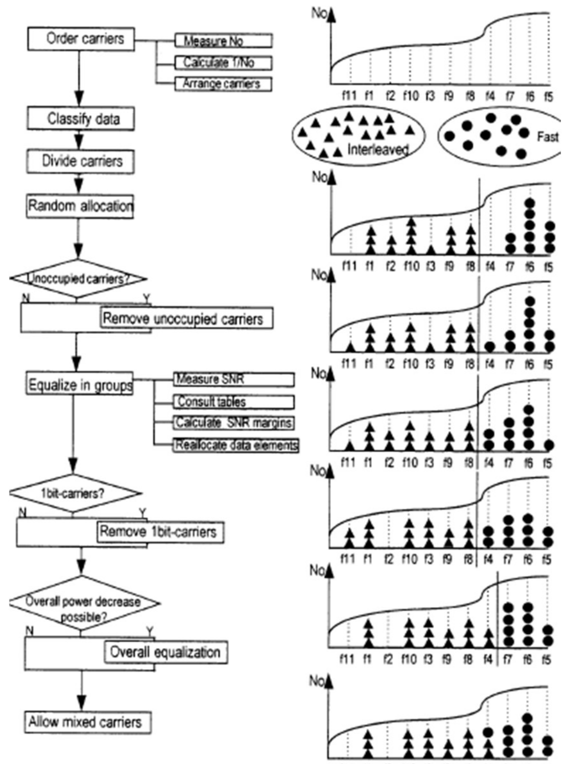
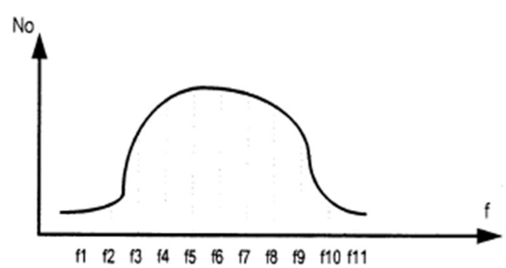
Nokia reserves the right to amend or supplement this claim chart at a later date.

Claim 10	Peeters Disclosure
[10-pre] A multicarrier communications transceiver operable to:	To the extent that the preamble is deemed limiting, under at least TQ Delta's apparent theory of infringement, Peeters discloses and/or renders obvious a multicarrier communications transceiver operable to: Fig. 1 is a block scheme of an embodiment of a Discrete Multi Tone (DMT) modulator which includes a mapping unit according to the present invention; *See, e.g.*, Peeters at 4:6-7.

Claim 10	Peeters Disclosure
	Referring to Fig. 1, a Discrete Multi Tone (DMT) modulator MOD used in asymmetrical digital subscriber line (ADSL) applications will be described. This modulator MOD includes a mapping unit MAP which allocates data elements to a set of 256 carriers according to the present invention. First, the working of the modulator MOD will be explained by means of a functional description of the blocks shown in Fig. 1. Based on this description, implementation of the functional blocks in Fig. 1 will be obvious to a person skilled in the art. In addition, the mapping unit MAP and allocation technique performed thereby will be described in further detail. *See, e.g.*, Peeters at 4:18-23. It has to be noted that although the described embodiment of the modulator is used in ADSL applications, the present method can be implemented in other transmission systems too, e.g. coax cable applications such as DMT (Discrete Multi Tone) for coax, radio transmission applications such as DVB (Digital Video Broadcast), DAB (Digital Audio Broadcast) and mobile communication. *See, e.g.*, Peeters at 7:54-57.  Fig. 1 *See, e.g.*, Peeters at Figure 1. To the extent TQ Delta alleges that this limitation is not fully disclosed by Peeters, this element would have been obvious to one of ordinary skill in the art based on the state of the art in existence at the time, the explicit and implicit teachings of this reference and the art, the

Claim 10	Peeters Disclosure
	differences between the art and the claimed limitation and the general knowledge of a person of ordinary skill in the art. A multicarrier communications transceiver was well known in the art. For example, each of the references in charts F10-354A – F10-354F and F10 Secondary - 354 teach this limitation. It would have been obvious to one of ordinary skill in the art to combine the teachings of Peeters with any of these references, as they all teach systems, apparatuses, or methods related to communication technologies involving multicarrier modulation.
[10A] receive a multicarrier symbol comprising a first plurality of carriers and a second plurality of carriers;	Under at least TQ Delta's apparent theory of infringement, Peeters discloses and/or renders obvious to receive a multicarrier symbol comprising a first plurality of carriers and a second plurality of carriers: Such a method and such equipment to perform the method are already known in the art, e.g. from the *US Patent 4,679,227, entitled 'Ensemble modem structure for imperfect transmission media' from the inventor Dirk Hughes-Hartogs*. Therein, a modem is described which transmits and receives digital data on a set of carriers called an ensemble of carrier frequencies. The modem includes a system for variably allocating data elements or data, and power to the carrier frequencies to be transmitted via a telephone line. In a first step, the method performed by this data and power allocating system determines for each carrier frequency the equivalent noise component. Obviously, this is equal to measuring for each carrier frequency the signal noise ratio (SNR) provided that the signal power during this measurement equals 1 power unit. As is described on lines 21-24 of column 11 of the above mentioned US Patent, the equivalent noise components are used in combination with the signal noise ratios necessary for transmission of the data elements with a given maximum bit error rate (BER) to calculate therefrom the required transmission power levels, marginal required power levels for each carrier frequency and data element allocation. As stated on lines 26-27 of column 11 of US Patent 4,679,227, these signal noise ratios necessary for transmission of the data elements are well known in the art, and are found in a table which is called a 'required SNR per data element'-table in the present patent application. The data elements in the known method are then allocated one by one to the carriers requiring the lowest power cost to increase the constellation complexity. In this way, the known method and modem provide a data element allocation to compensate for equivalent noise and to maximize the overall data transmission rate. The known method and modem however treat all data elements in an identical way. In communication networks transporting data elements for different applications and services, the requirements for noise compensation, bit error rate, data transmission rate, bandwidth and so on, may depend on the type of application or service. Several types of data, each of which characterized by its own requirements and specifications, can thus be distinguished.

Claim 10	Peeters Disclosure
	An object of the present invention is to provide a method and equipment of the above known type but which take into account data depending requirements for noise compensation, transmission rate and so on, and wherein data element allocation and transmission for each type of data are thus tuned to its own specifications. According to the invention, this object is achieved in the method, mapping unit and modulator described in claims 1, 13 and 14 respectively. Indeed, in the method described in claim 1, data elements are, according to a predetermined data criterion, e.g. the maximum allowable bit error rate, the required bandwidth, the required data transmission rate, the required compensation for noise, the required compensation for burst errors, ..., or a combination thereof, classified into N groups of data elements. Each group of data elements becomes modulated on a subset of carriers, these carriers being selected out of the full available set of carriers in accordance with another specific criterion, called a predetermined carrier criterion, e.g. the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, ... Based on the relation between data and carrier criteria, the N groups of data elements are linked one by one to the N subsets of carriers. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data. In addition, by using signal noise ratio measurements in combination with information from a 'required SNR per data element'-table, a distribution of data elements requiring the lowest overall power transmission is found in a similar way as described in the earlier cited US Patent, noticing that each group of data elements in the present method is related to its own 'required SNR per data element'-table which renders the allocation method more accurate. A further feature of the present data allocation method is that in a particular first implementation thereof, the predetermined data criterion is equal to service dependent required compensation for occasional noise increase. Telephone service for example will have lower requirements with respect to protection against occasional noise increase than telebanking service wherein all data have to be transmitted faultless. The predetermined carrier criterion in this first implementation is defined as the sensitivity of a carrier for such occasional noise increase. As follows from claims 3 and 4, different sources of such occasional noise increase can be thought off. Burst errors on transmission links in a network for example may damage a sequence of data elements and should thus be seen as a first type of occasional noise increase. A well known technique for compensation of such burst errors is the addition of an error protection code in combination with interleaving of data elements. Such an error protection code adds redundancy at the cost of user data transmission rate whilst interleaving introduces delay effects which enlarge when the depth of interleaving increases. In a particular embodiment of the above mentioned first implementation of the present method, the length of a possibly used error protection code and the complexity of a possibly applied interleaving are minimized by allocating data provided by services with high error compensation requirements to carriers which are least sensitive for these errors. *See, e.g.*, Peeters at 2:6-55. It has to be noted that although the described embodiment of the modulator is used in ADSL applications, the present method can be implemented in other transmission systems too, e.g. coax cable applications such as DMT (Discrete Multi Tone) for coax, radio transmission applications such as DVB (Digital Video Broadcast), DAB (Digital Audio Broadcast) and mobile communication. *See, e.g.*, Peeters at 7:54-57.

Claim 10	Peeters Disclosure
	 Fig. 2  Fig. 3

Claim 10	Peeters Disclosure

Number of bits allocated	Requested SNR (dB)
1	16
2	16
3	20
4	23
5	25

Number of bits allocated	Requested SNR (dB)
1	15
2	15
3	21
4	24
5	27

Fig. 4

Carrier	Measured SNR (dB)
f11	17
f1	22
f2	16
f10	22
f3	23
f9	19
f8	22
f4	23
f7	26
f6	26
f5	18

Fig. 5

See, e.g., Peeters at Figures 2-5.

To the extent TQ Delta alleges that this limitation is not fully disclosed by Peeters, this element would have been obvious to one of ordinary skill in the art based on the state of the art in existence at the time, the explicit and implicit teachings of this reference and the art, the differences between the art and the claimed limitation and the general knowledge of a person of ordinary skill in the art.

It was well known in the art to receive a multicarrier symbol comprising a first plurality of carriers and a second plurality of carriers. For example, each of the references in charts F10-354A – F10-354F and F10 Secondary - 354 teach this limitation. It would have been obvious to one of ordinary skill in the art to combine the teachings of Peeters with any of these references, as they all teach systems, apparatuses, or methods related to communication technologies involving multicarrier modulation.

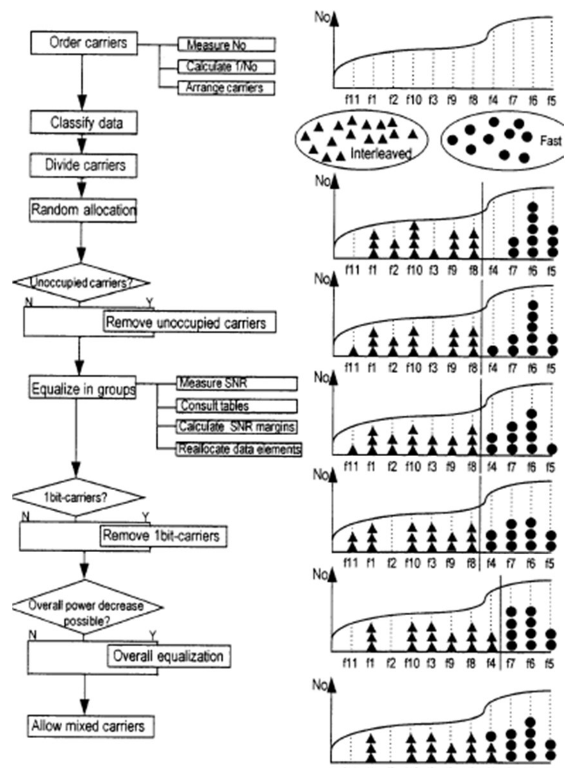
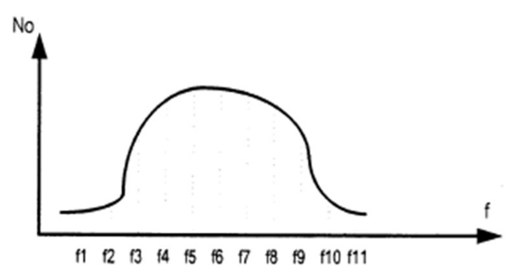
Claim 10	Peeters Disclosure
[10B] receive a first plurality of bits on the first plurality of carriers using a first SNR margin;	Under at least TQ Delta's apparent theory of infringement, Peeters discloses and/or renders obvious to receive a first plurality of bits on the first plurality of carriers using a first SNR margin: (57) To allocate a number of data elements to a set of carriers, the carriers are divided into N subsets of carriers according to a predetermined carrier criterion whilst the data elements are classified into N groups of data elements according to a predetermined data criterion, N being an integer. The predetermined data and carrier criterion have a relation on the basis of which the N subsets of carriers are associated one by one to the N groups of data elements. The data elements classified in such a group are then allowed to be modulated only on carriers which form part of the subset associated with this group. In addition, for each subset of carriers and related group of data elements the distribution is obtained by means of information from subset dependent 'required SNR (Signal Noise Ratio) per data element'-tables and previously carried out SNR measurements for each carrier. *See, e.g.*, Peeters at Abstract.

Claim 10	Peeters Disclosure
	According to the invention, this object is achieved in the method, mapping unit and modulator described in claims 1, 13 and 14 respectively. Indeed, in the method described in claim 1, data elements are, according to a predetermined data criterion, e.g. the maximum allowable bit error rate, the required bandwidth, the required data transmission rate, the required compensation for noise, the required compensation for burst errors, ..., or a combination thereof, classified into N groups of data elements. Each group of data elements becomes modulated on a subset of carriers, these carriers being selected out of the full available set of carriers in accordance with another specific criterion, called a predetermined carrier criterion, e.g. the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, ... Based on the relation between data and carrier criteria, the N groups of data elements are linked one by one to the N subsets of carriers. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data. In addition, by using signal noise ratio measurements in combination with information from a 'required SNR per data element'-table, a distribution of data elements requiring the lowest overall power transmission is found in a similar way as described in the earlier cited US Patent, noticing that each group of data elements in the present method is related to its own 'required SNR per data element'-table which renders the allocation method more accurate. A further feature of the present data allocation method is that in a particular first implementation thereof, the predetermined data criterion is equal to service dependent required compensation for occasional noise increase. Telephone service for example will have lower requirements with respect to protection against occasional noise increase than telebanking service wherein all data have to be transmitted faultless. The predetermined carrier criterion in this first implementation is defined as the sensitivity of a carrier for such occasional noise increase. As follows from claims 3 and 4, different sources of such occasional noise increase can be thought off. Burst errors on transmission links in a network for example may damage a sequence of data elements and should thus be seen as a first type of occasional noise increase. A well known technique for compensation of such burst errors is the addition of an error protection code in combination with interleaving of data elements. Such an error protection code adds redundancy at the cost of user data transmission rate whilst interleaving introduces delay effects which enlarge when the depth of interleaving increases. In a particular embodiment of the above mentioned first implementation of the present method, the length of a possibly used error protection code and the complexity of a possibly applied interleaving are minimized by allocating data provided by services with high error compensation requirements to carriers which are least sensitive for these errors. *See, e.g.*, Peeters at 2:29-55. Still a further characteristic feature of the present method is that the occupation of the carriers with data elements is improved by sharing N-1 carriers between two data element groups as is described in claim 8. In the present application, such carriers are called mixed carriers. To assign subsets of carriers to groups of data elements, all carriers are fictively arranged in increasing order or decreasing order of the predetermined carrier criterion (e.g. in increasing order of sensitivity of the carrier for burst errors). A first subset of e.g. 4 carriers is then associated with a first group of data elements, a second subset of e.g. 7 carriers is associated with a second group of data elements having e.g. lower noise compensation requirements than the first group of data elements, and so on. Once having allocated the data elements, the fourth carrier of the first subset however may be partially unoccupied by data elements of the first group and therefore can be used as a mixed carrier, to which also data elements of the second group are allocated. By extrapolation of the above example, it is seen that for N groups of data elements, a maximum amount of N-1 mixed carriers is thus allowed.

Claim 10	Peeters Disclosure
	Still another characteristic feature is that the present data allocation method is dedicated to minimize overall power transmission. This means that, once the allocation is performed, it has become impossible to reduce the overall power transmission by removing a data element from the carrier whereto it is allocated to another carrier. The possibility to reduce the overall power transmission by removing a data element from a carrier to another carrier forming part of the same subset of carriers is eliminated by applying the waterfilling principle described in the already cited US Patent to distribute data elements of a group of data elements to carriers of the associated subset of carriers. In an implementation of this waterfilling principle, data elements can be allocated one by one to the carrier having the largest signal noise ratio margin. This signal noise ratio margin therefor has to be calculated for each carrier by subtracting from the signal noise ratio value measured for this carrier, the required signal noise ratio value to enable allocating data elements thereto. This required signal noise ratio value is found in the 'required SNR per data element'-tables already mentioned. On the other hand, the possibility to reduce overall power transmission by applying another partition into subsets of carriers has to be eliminated. Whenever this possibility exists, the carriers should be redivided into subsets of carriers which are tuned better to the number of data elements in the different groups. Such a situation would occur when a large number of data elements is allocated to a subset of carriers with a small capacity with respect to the 'required SNR per data element'-table specific to this subset, whilst a small number of data elements is allocated to a subset of carriers with a large capacity with respect to the 'required SNR per data element'-table specific to this latter subset. In the latter subset of carriers, the signal noise ratio margins will be large, whilst in the former subset of carriers, signal noise ratio margins will be small. *See, e.g.*, Peeters at 3:14-42. The present invention more specifically relates to the mapping unit MAP and algorithm executed by the processor PROC therein to allocate data elements applied to the first input I1 to the set of 256 carriers. In the following paragraphs, a detailed description of this algorithm and means included in the mapping unit MAP thereto will be given. However, to avoid overloading the figures accompanying the description of the algorithm, the particular situation is chosen wherein 26 data elements have to be allocated to a set of 11 carriers referred to as f1, ..., f11. Obviously, the algorithm to allocate data elements to a set of 256 carriers is not different from the algorithm to allocate data elements to 11 carriers. Extrapolation of the algorithm described in the following paragraphs is thus obvious to a person skilled in the art. The Discrete Multi Tone modulator MOD of the preferred embodiment forms part of a full service network not shown in the drawings. The data elements applied to the first input I1 of the processor PROC thus originate from a plurality of services, each of these services having its own requirements and specifications. Telephone speech data or video data for example are requiring less protection against burst errors than telebanking data. On the other hand, telebanking data may be delayed. Besides, it is well known that a carrier property such as the sensitivity for burst errors is frequency dependent and thus different for each of the above mentioned 256 carriers. From these establishments, it follows that some carriers are more likely to be used for modulation of data generated by a particular service than others. In the first three steps of the allocation method performed by the mapper MAP, carriers and data elements will therefore be arranged in subsets and groups according to their properties and requirements respectively. These groups of data elements and subsets of carriers will then be associated to each other in such a way that data elements become allocated to carriers which are tuned to their specific service dependent requirements. In five additional steps, the data elements of each group are distributed over the carriers of the associated subset in order to obtain a satisfying distribution. *See, e.g.*, Peeters at 5:13-32.

Claim 10	Peeters Disclosure
	The mapper MAP of Fig. 1 for the description in the following paragraphs is supposed to classify the data elements in 2 groups: a group of interleaved data and a group of fast data. The classification is performed based upon the requirements with respect to burst error correction for the data elements as well as to acceptable latency. Indeed, data elements which need to be protected against burst errors will be interleaved and therefore will be allocated to carriers with a high sensitivity for burst errors since for these carriers, protection by interleaving is provided. On the contrary, data such as telephone speech data, which have lower requirements with respect to protection against burst errors but are delay sensitive, will not be interleaved but can be allocated to carriers which are less sensitive for burst errors. *See, e.g.*, Peeters at 5:38-44. In the second step of the algorithm, the mapping unit MAP of Fig. 1 classifies the incoming data elements in 2 groups. As already explained, the requirements with respect to interleaving are used as a criterion for this classification. Once classified, each data element can be considered to carry a label defining whether it forms part of the group of interleaved data or of the group of fast data. In the graphs of Fig. 2 this is shown by representing each data element classified in the group of interleaved data by a small triangle, whilst representing the data elements of the group of fast data by small circles. It is further seen in Fig. 2 that 26 data elements have to be classified in these two groups: 16 data elements thereof belong to group 1, whilst the remaining 10 data elements belong to the second group of fast data. It has to be noticed that in an alternative implementation of the present invention, the data elements are already carrying a label similar to the just mentioned labels when entering the modulator MOD in such a way that it is no longer a task of the mapping unit MAP to partition the data elements in groups. *See, e.g.*, Peeters at 6:23-32. As is seen in the second graph two carriers, one of which belongs to subset 1 and the second of which belongs to subset 2, are left unoccupied. Therefore, in step 5, data elements are removed to obtain new constellations without unoccupied carriers. To decide which data elements are removed, the 'required SNR per data element'-tables are consulted. Such a table exists for both subsets of carriers and these tables are stored in 2 table memories similar to the table memories TM1 ... TMN shown in Fig. 1. Such a 'required SNR per data element'-table, as already said in the introduction, is well known in the art. In the present method however, a plurality of these tables is used since each subgroup of carriers has its own table. The two tables corresponding to subset 1 and subset 2 are shown in Fig. 4. Therein, the left table corresponds to subset 1 and the right table corresponds to subset 2. The measured SNR values for each of the carriers f1 ... f11 are listed in the table of Fig. 5. For each carrier, the SNR margin is calculated. These SNR margins are first calculated for each carrier in subset 1 by subtracting the requested SNR from the SNR value measured on each of these carriers. Carrier f1 for example carries 3 data bits in step 4. The SNR measured on f1 equals 22 dB whilst the required SNR allowing f1 to carry 3 data bits is equal to 20 dB. As a result, the SNR margin for f1 equals 2 dB. The SNR margins similarly calculated for f2, f10, f3, f9 and f8 are equal to 0 dB, -1 dB, 7 dB, -1 dB and 2 dB respectively. Since the minimum overall SNR margin equals the overall power decrease that can be performed, data elements are removed from a carrier to an unoccupied carrier in such a way that the minimum SNR margin increases as much as possible. Two carriers, f10 and f9 have an SNR margin of -1 dB. Since 4 data bits are allocated to f10 and 3 data bits are assigned to f9, f10 is more noise sensitive than f9. Therefore, a data bit is removed from f10 to f11. When the same procedure is applied to the second group of fast data elements in Fig. 2, the constellation drawn for step 4 changes into the constellation drawn for step 5.

Claim 10	Peeters Disclosure
	In the sixth step, the data element allocations are equalised within each group. To perform this equalising the signal noise ratio (SNR) measurements, supplied to the processor PROC via its second input I2, are again compared to the required signal noise ratio values stored in the 'required SNR per data element'-tables and applied to the processor PROC via I3. Data elements of the first group are removed from carriers of subset 1 and allocated to other carriers of subset 1 to thereby maximize the minimum SNR margin within this group. The SNR margins for f11, f1, f2, f10, f3, f9 and f8, calculated as already described above, are equal to 1 dB, 2 dB, 0 dB, 2 dB, 7 dB, -1 dB and 2 dB. To increase the minimum SNR margin, a data bit then is removed from the carrier with least SNR margin to the carrier that has the highest SNR margin after this data bit has been added thereto. In the example of Fig. 2, a data bit, previously allocated to f9 is thus removed therefrom and becomes assigned to carrier f3. As a result, the SNR margin of f9 increases from -1 dB to 3 dB, whilst the SNR margin of f3 remains 7 dB. A further data bit, carried by f2, is not removed therefrom to be added to f3 since this would imply a reduction of the SNR margin of f3 to 3 dB without increase of the SNR margin of f2. The same procedure is followed for equalising the fast data elements allocated to the second subset of carriers. When equalising all data elements in the interleaved group and fast group in such a way that the minimum remaining SNR margins for all carriers within each group are maximized, the constellation shown in the graph attached to step 6 in Fig. 2 is obtained. According to the draft ADSL Standard, one bit constellations have to be removed. In step 7 it is therefore checked whether such 1 bit constellations exist or not. If 1 bit constellations are detected, they are upgraded to two bit constellations by removing once more bits from other carriers in a way similar to step 5. It can be seen from the graph attached to step 7 in Fig. 2 that carriers f11 and f5 no longer carry only 1 bit. By removing a first data bit from f2 to f11 and a second data bit from f2 to f3, the SNR margin of f2 is increased from 0 dB to 16 dB. The SNR margin of f11 on the other hand is left unmodified and still equals 1 dB. For each subset of carriers, an optimal data bit allocation is obtained now, i.e. an allocation is found with maximal minimum SNR margins. For subset 1 this minimum SNR margin is equal to 1 dB, for subset 2 the minimum SNR margin equals 3 dB. An overall power decrease of 1 dB can thus be applied if no further steps are performed. *See, e.g.*, Peeters at 6:51-7:34.

Claim 10	Peeters Disclosure
	 Fig. 2  Fig. 3

Claim 10	Peeters Disclosure
	(see tables below)

Number of bits allocated	Requested SNR (dB)
1	16
2	16
3	20
4	23
5	25

Number of bits allocated	Requested SNR (dB)
1	15
2	15
3	21
4	24
5	27

Fig. 4

Carrier	Measured SNR (dB)
f11	17
f1	22
f2	16
f10	22
f3	23
f9	19
f8	22
f4	23
f7	26
f6	26
f5	18

Fig. 5

See, e.g., Peeters at Figures 2-5.

To the extent TQ Delta alleges that this limitation is not fully disclosed by Peeters, this element would have been obvious to one of ordinary skill in the art based on the state of the art in existence at the time, the explicit and implicit teachings of this reference and the art, the differences between the art and the claimed limitation and the general knowledge of a person of ordinary skill in the art.

It was well known in the art to receive a first plurality of bits on the first plurality of carriers using a first SNR margin. For example, each of the references in charts F10-354A – F10-354F and F10 Secondary - 354 teach this limitation. It would have been obvious to one of ordinary skill in the art to combine the teachings of Peeters with any of these references, as they all teach systems, apparatuses, or methods related to communication technologies involving multicarrier modulation.

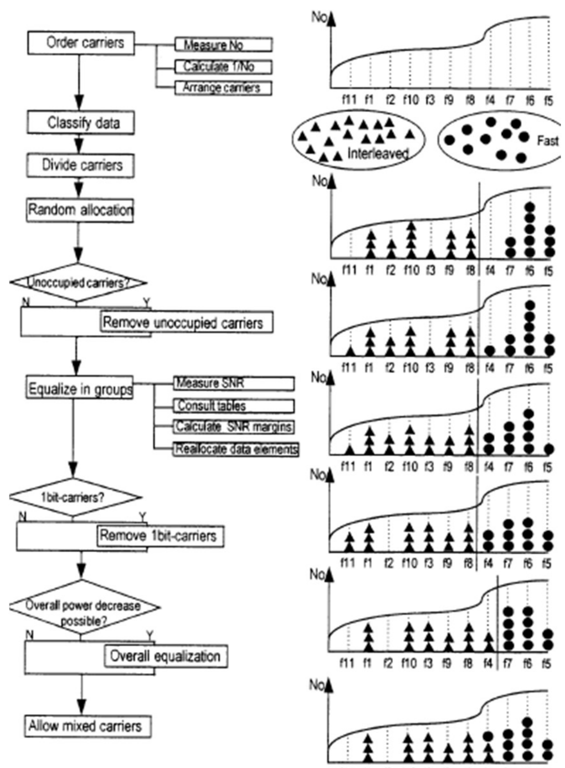
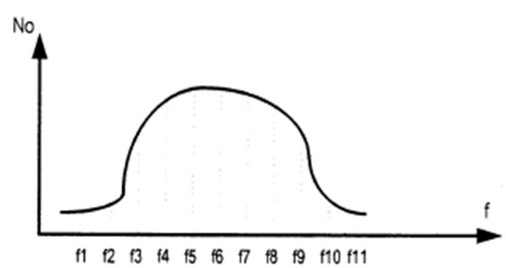
Claim 10	Peeters Disclosure
[10C] receive a second plurality of bits on the second plurality of carriers using a second SNR margin;	Under at least TQ Delta's apparent theory of infringement, Peeters discloses and/or renders obvious to receive a second plurality of bits on the second plurality of carriers using a second SNR margin: (57) To allocate a number of data elements to a set of carriers, the carriers are divided into N subsets of carriers according to a predetermined carrier criterion whilst the data elements are classified into N groups of data elements according to a predetermined data criterion, N being an integer. The predetermined data and carrier criterion have a relation on the basis of which the N subsets of carriers are associated one by one to the N groups of data elements. The data elements classified in such a group are then allowed to be modulated only on carriers which form part of the subset associated with this group. In addition, for each subset of carriers and related group of data elements the distribution is obtained by means of information from subset dependent 'required SNR (Signal Noise Ratio) per data element'-tables and previously carried out SNR measurements for each carrier. *See, e.g.*, Peeters at Abstract.

Claim 10	Peeters Disclosure
	According to the invention, this object is achieved in the method, mapping unit and modulator described in claims 1, 13 and 14 respectively. Indeed, in the method described in claim 1, data elements are, according to a predetermined data criterion, e.g. the maximum allowable bit error rate, the required bandwidth, the required data transmission rate, the required compensation for noise, the required compensation for burst errors, ..., or a combination thereof, classified into N groups of data elements. Each group of data elements becomes modulated on a subset of carriers, these carriers being selected out of the full available set of carriers in accordance with another specific criterion, called a predetermined carrier criterion, e.g. the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, ... Based on the relation between data and carrier criteria, the N groups of data elements are linked one by one to the N subsets of carriers. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data. In addition, by using signal noise ratio measurements in combination with information from a 'required SNR per data element'-table, a distribution of data elements requiring the lowest overall power transmission is found in a similar way as described in the earlier cited US Patent, noticing that each group of data elements in the present method is related to its own 'required SNR per data element'-table which renders the allocation method more accurate. A further feature of the present data allocation method is that in a particular first implementation thereof, the predetermined data criterion is equal to service dependent required compensation for occasional noise increase. Telephone service for example will have lower requirements with respect to protection against occasional noise increase than telebanking service wherein all data have to be transmitted faultless. The predetermined carrier criterion in this first implementation is defined as the sensitivity of a carrier for such occasional noise increase. As follows from claims 3 and 4, different sources of such occasional noise increase can be thought off. Burst errors on transmission links in a network for example may damage a sequence of data elements and should thus be seen as a first type of occasional noise increase. A well known technique for compensation of such burst errors is the addition of an error protection code in combination with interleaving of data elements. Such an error protection code adds redundancy at the cost of user data transmission rate whilst interleaving introduces delay effects which enlarge when the depth of interleaving increases. In a particular embodiment of the above mentioned first implementation of the present method, the length of a possibly used error protection code and the complexity of a possibly applied interleaving are minimized by allocating data provided by services with high error compensation requirements to carriers which are least sensitive for these errors. *See, e.g.*, Peeters at 2:29-55. Still a further characteristic feature of the present method is that the occupation of the carriers with data elements is improved by sharing N-1 carriers between two data element groups as is described in claim 8. In the present application, such carriers are called mixed carriers. To assign subsets of carriers to groups of data elements, all carriers are fictively arranged in increasing order or decreasing order of the predetermined carrier criterion (e.g. in increasing order of sensitivity of the carrier for burst errors). A first subset of e.g. 4 carriers is then associated with a first group of data elements, a second subset of e.g. 7 carriers is associated with a second group of data elements having e.g. lower noise compensation requirements than the first group of data elements, and so on. Once having allocated the data elements, the fourth carrier of the first subset however may be partially unoccupied by data elements of the first group and therefore can be used as a mixed carrier, to which also data elements of the second group are allocated. By extrapolation of the above example, it is seen that for N groups of data elements, a maximum amount of N-1 mixed carriers is thus allowed.

Claim 10	Peeters Disclosure
	Still another characteristic feature is that the present data allocation method is dedicated to minimize overall power transmission. This means that, once the allocation is performed, it has become impossible to reduce the overall power transmission by removing a data element from the carrier whereto it is allocated to another carrier. The possibility to reduce the overall power transmission by removing a data element from a carrier to another carrier forming part of the same subset of carriers is eliminated by applying the waterfilling principle described in the already cited US Patent to distribute data elements of a group of data elements to carriers of the associated subset of carriers. In an implementation of this waterfilling principle, data elements can be allocated one by one to the carrier having the largest signal noise ratio margin. This signal noise ratio margin therefor has to be calculated for each carrier by subtracting from the signal noise ratio value measured for this carrier, the required signal noise ratio value to enable allocating data elements thereto. This required signal noise ratio value is found in the 'required SNR per data element'-tables already mentioned. On the other hand, the possibility to reduce overall power transmission by applying another partition into subsets of carriers has to be eliminated. Whenever this possibility exists, the carriers should be redivided into subsets of carriers which are tuned better to the number of data elements in the different groups. Such a situation would occur when a large number of data elements is allocated to a subset of carriers with a small capacity with respect to the 'required SNR per data element'-table specific to this subset, whilst a small number of data elements is allocated to a subset of carriers with a large capacity with respect to the 'required SNR per data element'-table specific to this latter subset. In the latter subset of carriers, the signal noise ratio margins will be large, whilst in the former subset of carriers, signal noise ratio margins will be small. *See, e.g.*, Peeters at 3:14-42. The present invention more specifically relates to the mapping unit MAP and algorithm executed by the processor PROC therein to allocate data elements applied to the first input I1 to the set of 256 carriers. In the following paragraphs, a detailed description of this algorithm and means included in the mapping unit MAP thereto will be given. However, to avoid overloading the figures accompanying the description of the algorithm, the particular situation is chosen wherein 26 data elements have to be allocated to a set of 11 carriers referred to as f1, ..., f11. Obviously, the algorithm to allocate data elements to a set of 256 carriers is not different from the algorithm to allocate data elements to 11 carriers. Extrapolation of the algorithm described in the following paragraphs is thus obvious to a person skilled in the art. The Discrete Multi Tone modulator MOD of the preferred embodiment forms part of a full service network not shown in the drawings. The data elements applied to the first input I1 of the processor PROC thus originate from a plurality of services, each of these services having its own requirements and specifications. Telephone speech data or video data for example are requiring less protection against burst errors than telebanking data. On the other hand, telebanking data may be delayed. Besides, it is well known that a carrier property such as the sensitivity for burst errors is frequency dependent and thus different for each of the above mentioned 256 carriers. From these establishments, it follows that some carriers are more likely to be used for modulation of data generated by a particular service than others. In the first three steps of the allocation method performed by the mapper MAP, carriers and data elements will therefore be arranged in subsets and groups according to their properties and requirements respectively. These groups of data elements and subsets of carriers will then be associated to each other in such a way that data elements become allocated to carriers which are tuned to their specific service dependent requirements. In five additional steps, the data elements of each group are distributed over the carriers of the associated subset in order to obtain a satisfying distribution. *See, e.g.*, Peeters at 5:13-32.

Claim 10	Peeters Disclosure
	The mapper MAP of Fig. 1 for the description in the following paragraphs is supposed to classify the data elements in 2 groups: a group of interleaved data and a group of fast data. The classification is performed based upon the requirements with respect to burst error correction for the data elements as well as to acceptable latency. Indeed, data elements which need to be protected against burst errors will be interleaved and therefore will be allocated to carriers with a high sensitivity for burst errors since for these carriers, protection by interleaving is provided. On the contrary, data such as telephone speech data, which have lower requirements with respect to protection against burst errors but are delay sensitive, will not be interleaved but can be allocated to carriers which are less sensitive for burst errors. *See, e.g.*, Peeters at 5:38-44. In the second step of the algorithm, the mapping unit MAP of Fig. 1 classifies the incoming data elements in 2 groups. As already explained, the requirements with respect to interleaving are used as a criterion for this classification. Once classified, each data element can be considered to carry a label defining whether it forms part of the group of interleaved data or of the group of fast data. In the graphs of Fig. 2 this is shown by representing each data element classified in the group of interleaved data by a small triangle, whilst representing the data elements of the group of fast data by small circles. It is further seen in Fig. 2 that 26 data elements have to be classified in these two groups: 16 data elements thereof belong to group 1, whilst the remaining 10 data elements belong to the second group of fast data. It has to be noticed that in an alternative implementation of the present invention, the data elements are already carrying a label similar to the just mentioned labels when entering the modulator MOD in such a way that it is no longer a task of the mapping unit MAP to partition the data elements in groups. *See, e.g.*, Peeters at 6:23-32. As is seen in the second graph two carriers, one of which belongs to subset 1 and the second of which belongs to subset 2, are left unoccupied. Therefore, in step 5, data elements are removed to obtain new constellations without unoccupied carriers. To decide which data elements are removed, the 'required SNR per data element'-tables are consulted. Such a table exists for both subsets of carriers and these tables are stored in 2 table memories similar to the table memories TM1 ... TMN shown in Fig. 1. Such a 'required SNR per data element'-table, as already said in the introduction, is well known in the art. In the present method however, a plurality of these tables is used since each subgroup of carriers has its own table. The two tables corresponding to subset 1 and subset 2 are shown in Fig. 4. Therein, the left table corresponds to subset 1 and the right table corresponds to subset 2. The measured SNR values for each of the carriers f1 ... f11 are listed in the table of Fig. 5. For each carrier, the SNR margin is calculated. These SNR margins are first calculated for each carrier in subset 1 by subtracting the requested SNR from the SNR value measured on each of these carriers. Carrier f1 for example carries 3 data bits in step 4. The SNR measured on f1 equals 22 dB whilst the required SNR allowing f1 to carry 3 data bits is equal to 20 dB. As a result, the SNR margin for f1 equals 2 dB. The SNR margins similarly calculated for f2, f10, f3, f9 and f8 are equal to 0 dB, -1 dB, 7 dB, -1 dB and 2 dB respectively. Since the minimum overall SNR margin equals the overall power decrease that can be performed, data elements are removed from a carrier to an unoccupied carrier in such a way that the minimum SNR margin increases as much as possible. Two carriers, f10 and f9 have an SNR margin of -1 dB. Since 4 data bits are allocated to f10 and 3 data bits are assigned to f9, f10 is more noise sensitive than f9. Therefore, a data bit is removed from f10 to f11. When the same procedure is applied to the second group of fast data elements in Fig. 2, the constellation drawn for step 4 changes into the constellation drawn for step 5.

Claim 10	Peeters Disclosure
	In the sixth step, the data element allocations are equalised within each group. To perform this equalising the signal noise ratio (SNR) measurements, supplied to the processor PROC via its second input I2, are again compared to the required signal noise ratio values stored in the 'required SNR per data element'-tables and applied to the processor PROC via I3. Data elements of the first group are removed from carriers of subset 1 and allocated to other carriers of subset 1 to thereby maximize the minimum SNR margin within this group. The SNR margins for f11, f1, f2, f10, f3, f9 and f8, calculated as already described above, are equal to 1 dB, 2 dB, 0 dB, 2 dB, 7 dB, -1 dB and 2 dB. To increase the minimum SNR margin, a data bit then is removed from the carrier with least SNR margin to the carrier that has the highest SNR margin after this data bit has been added thereto. In the example of Fig. 2, a data bit, previously allocated to f9 is thus removed therefrom and becomes assigned to carrier f3. As a result, the SNR margin of f9 increases from -1 dB to 3 dB, whilst the SNR margin of f3 remains 7 dB. A further data bit, carried by f2, is not removed therefrom to be added to f3 since this would imply a reduction of the SNR margin of f3 to 3 dB without increase of the SNR margin of f2. The same procedure is followed for equalising the fast data elements allocated to the second subset of carriers. When equalising all data elements in the interleaved group and fast group in such a way that the minimum remaining SNR margins for all carriers within each group are maximized, the constellation shown in the graph attached to step 6 in Fig. 2 is obtained. According to the draft ADSL Standard, one bit constellations have to be removed. In step 7 it is therefore checked whether such 1 bit constellations exist or not. If 1 bit constellations are detected, they are upgraded to two bit constellations by removing once more bits from other carriers in a way similar to step 5. It can be seen from the graph attached to step 7 in Fig. 2 that carriers f11 and f5 no longer carry only 1 bit. By removing a first data bit from f2 to f11 and a second data bit from f2 to f3, the SNR margin of f2 is increased from 0 dB to 16 dB. The SNR margin of f11 on the other hand is left unmodified and still equals 1 dB. For each subset of carriers, an optimal data bit allocation is obtained now, i.e. an allocation is found with maximal minimum SNR margins. For subset 1 this minimum SNR margin is equal to 1 dB, for subset 2 the minimum SNR margin equals 3 dB. An overall power decrease of 1 dB can thus be applied if no further steps are performed. *See, e.g.*, Peeters at 6:51-7:34.

Claim 10	Peeters Disclosure
	 Fig. 2  Fig. 3

Claim 10	Peeters Disclosure
	(Fig. 4 and Fig. 5 tables below)

Number of bits allocated	Requested SNR (dB)
1	16
2	16
3	20
4	23
5	25

Number of bits allocated	Requested SNR (dB)
1	15
2	15
3	21
4	24
5	27

Fig. 4

Carrier	Measured SNR (dB)
f11	17
f1	22
f2	16
f10	22
f3	23
f9	19
f8	22
f4	23
f7	26
f6	26
f5	18

Fig. 5

See, e.g., Peeters at Figures 2-5.

To the extent TQ Delta alleges that this limitation is not fully disclosed by Peeters, this element would have been obvious to one of ordinary skill in the art based on the state of the art in existence at the time, the explicit and implicit teachings of this reference and the art, the differences between the art and the claimed limitation and the general knowledge of a person of ordinary skill in the art.

It was well known in the art to receive a second plurality of bits on the second plurality of carriers using a second SNR margin. For example, each of the references in charts F10-354A – F10-354F and F10 Secondary - 354 teach this limitation. It would have been obvious to one of ordinary skill in the art to combine the teachings of Peeters with any of these references, as they all teach systems, apparatuses, or methods related to communication technologies involving multicarrier modulation.

<table>
<tr><th>Claim 10</th><th>Peeters Disclosure</th></tr>
<tr><td>[10D] wherein the first plurality of carriers is different than the second plurality of carriers,</td><td>Under at least TQ Delta’s apparent theory of infringement, Peeters discloses and/or renders obvious the first plurality of carriers is different than the second plurality of carriers:

(57) To allocate a number of data elements to a set of carriers, the carriers are divided into N subsets of carriers according to a predetermined carrier criterion whilst the data elements are classified into N groups of data elements according to a predetermined data criterion, N being an integer.

The predetermined data and carrier criterion have a relation on the basis of which the N subsets of carriers are associated one by one to the N groups of data elements. The data elements classified in such a group are then allowed to be modulated only on carriers which form part of the subset associated with this group.
In addition, for each subset of carriers and related group of data elements the distribution is obtained by means of information from subset dependent 'required SNR (Signal Noise Ratio) per data element'-tables and previously carried out SNR measurements for each carrier.

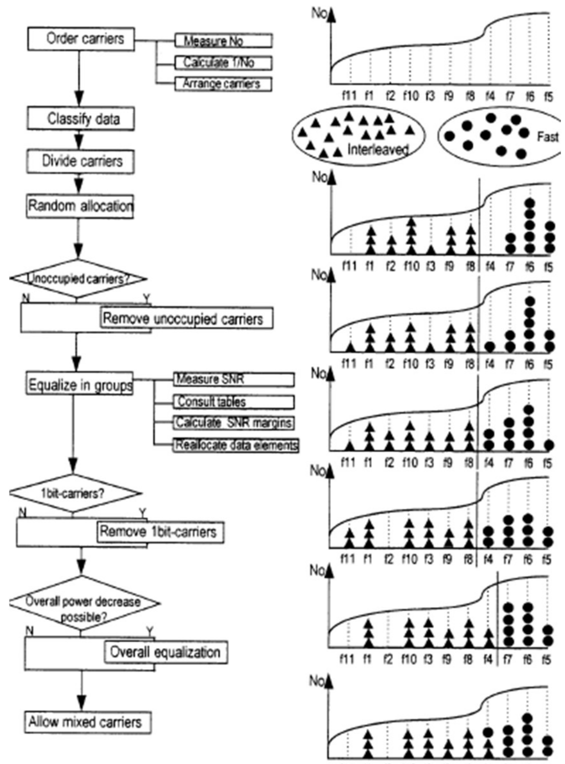
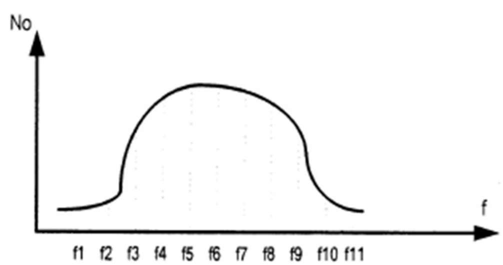
See, e.g., Peeters at Abstract.</td></tr>
</table>

Claim 10	Peeters Disclosure
	According to the invention, this object is achieved in the method, mapping unit and modulator described in claims 1, 13 and 14 respectively. Indeed, in the method described in claim 1, data elements are, according to a predetermined data criterion, e.g. the maximum allowable bit error rate, the required bandwidth, the required data transmission rate, the required compensation for noise, the required compensation for burst errors, ..., or a combination thereof, classified into N groups of data elements. Each group of data elements becomes modulated on a subset of carriers, these carriers being selected out of the full available set of carriers in accordance with another specific criterion, called a predetermined carrier criterion, e.g. the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, ... Based on the relation between data and carrier criteria, the N groups of data elements are linked one by one to the N subsets of carriers. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data. In addition, by using signal noise ratio measurements in combination with information from a 'required SNR per data element'-table, a distribution of data elements requiring the lowest overall power transmission is found in a similar way as described in the earlier cited US Patent, noticing that each group of data elements in the present method is related to its own 'required SNR per data element'-table which renders the allocation method more accurate. A further feature of the present data allocation method is that in a particular first implementation thereof, the predetermined data criterion is equal to service dependent required compensation for occasional noise increase. Telephone service for example will have lower requirements with respect to protection against occasional noise increase than telebanking service wherein all data have to be transmitted faultless. The predetermined carrier criterion in this first implementation is defined as the sensitivity of a carrier for such occasional noise increase. As follows from claims 3 and 4, different sources of such occasional noise increase can be thought off. Burst errors on transmission links in a network for example may damage a sequence of data elements and should thus be seen as a first type of occasional noise increase. A well known technique for compensation of such burst errors is the addition of an error protection code in combination with interleaving of data elements. Such an error protection code adds redundancy at the cost of user data transmission rate whilst interleaving introduces delay effects which enlarge when the depth of interleaving increases. In a particular embodiment of the above mentioned first implementation of the present method, the length of a possibly used error protection code and the complexity of a possibly applied interleaving are minimized by allocating data provided by services with high error compensation requirements to carriers which are least sensitive for these errors. *See, e.g.*, Peeters at 2:29-55. Still a further characteristic feature of the present method is that the occupation of the carriers with data elements is improved by sharing N-1 carriers between two data element groups as is described in claim 8. In the present application, such carriers are called mixed carriers. To assign subsets of carriers to groups of data elements, all carriers are fictively arranged in increasing order or decreasing order of the predetermined carrier criterion (e.g. in increasing order of sensitivity of the carrier for burst errors). A first subset of e.g. 4 carriers is then associated with a first group of data elements, a second subset of e.g. 7 carriers is associated with a second group of data elements having e.g. lower noise compensation requirements than the first group of data elements, and so on. Once having allocated the data elements, the fourth carrier of the first subset however may be partially unoccupied by data elements of the first group and therefore can be used as a mixed carrier, to which also data elements of the second group are allocated. By extrapolation of the above example, it is seen that for N groups of data elements, a maximum amount of N-1 mixed carriers is thus allowed.

Claim 10	Peeters Disclosure
	Still another characteristic feature is that the present data allocation method is dedicated to minimize overall power transmission. This means that, once the allocation is performed, it has become impossible to reduce the overall power transmission by removing a data element from the carrier whereto it is allocated to another carrier. The possibility to reduce the overall power transmission by removing a data element from a carrier to another carrier forming part of the same subset of carriers is eliminated by applying the waterfilling principle described in the already cited US Patent to distribute data elements of a group of data elements to carriers of the associated subset of carriers. In an implementation of this waterfilling principle, data elements can be allocated one by one to the carrier having the largest signal noise ratio margin. This signal noise ratio margin therefor has to be calculated for each carrier by subtracting from the signal noise ratio value measured for this carrier, the required signal noise ratio value to enable allocating data elements thereto. This required signal noise ratio value is found in the 'required SNR per data element'-tables already mentioned. On the other hand, the possibility to reduce overall power transmission by applying another partition into subsets of carriers has to be eliminated. Whenever this possibility exists, the carriers should be redivided into subsets of carriers which are tuned better to the number of data elements in the different groups. Such a situation would occur when a large number of data elements is allocated to a subset of carriers with a small capacity with respect to the 'required SNR per data element'-table specific to this subset, whilst a small number of data elements is allocated to a subset of carriers with a large capacity with respect to the 'required SNR per data element'-table specific to this latter subset. In the latter subset of carriers, the signal noise ratio margins will be large, whilst in the former subset of carriers, signal noise ratio margins will be small. *See, e.g.*, Peeters at 3:14-42. The present invention more specifically relates to the mapping unit MAP and algorithm executed by the processor PROC therein to allocate data elements applied to the first input I1 to the set of 256 carriers. In the following paragraphs, a detailed description of this algorithm and means included in the mapping unit MAP thereto will be given. However, to avoid overloading the figures accompanying the description of the algorithm, the particular situation is chosen wherein 26 data elements have to be allocated to a set of 11 carriers referred to as f1, ..., f11. Obviously, the algorithm to allocate data elements to a set of 256 carriers is not different from the algorithm to allocate data elements to 11 carriers. Extrapolation of the algorithm described in the following paragraphs is thus obvious to a person skilled in the art. The Discrete Multi Tone modulator MOD of the preferred embodiment forms part of a full service network not shown in the drawings. The data elements applied to the first input I1 of the processor PROC thus originate from a plurality of services, each of these services having its own requirements and specifications. Telephone speech data or video data for example are requiring less protection against burst errors than telebanking data. On the other hand, telebanking data may be delayed. Besides, it is well known that a carrier property such as the sensitivity for burst errors is frequency dependent and thus different for each of the above mentioned 256 carriers. From these establishments, it follows that some carriers are more likely to be used for modulation of data generated by a particular service than others. In the first three steps of the allocation method performed by the mapper MAP, carriers and data elements will therefore be arranged in subsets and groups according to their properties and requirements respectively. These groups of data elements and subsets of carriers will then be associated to each other in such a way that data elements become allocated to carriers which are tuned to their specific service dependent requirements. In five additional steps, the data elements of each group are distributed over the carriers of the associated subset in order to obtain a satisfying distribution. *See, e.g.*, Peeters at 5:13-32.

Claim 10	Peeters Disclosure
	The mapper MAP of Fig. 1 for the description in the following paragraphs is supposed to classify the data elements in 2 groups: a group of interleaved data and a group of fast data. The classification is performed based upon the requirements with respect to burst error correction for the data elements as well as to acceptable latency. Indeed, data elements which need to be protected against burst errors will be interleaved and therefore will be allocated to carriers with a high sensitivity for burst errors since for these carriers, protection by interleaving is provided. On the contrary, data such as telephone speech data, which have lower requirements with respect to protection against burst errors but are delay sensitive, will not be interleaved but can be allocated to carriers which are less sensitive for burst errors. *See, e.g.*, Peeters at 5:38-44. In the second step of the algorithm, the mapping unit MAP of Fig. 1 classifies the incoming data elements in 2 groups. As already explained, the requirements with respect to interleaving are used as a criterion for this classification. Once classified, each data element can be considered to carry a label defining whether it forms part of the group of interleaved data or of the group of fast data. In the graphs of Fig. 2 this is shown by representing each data element classified in the group of interleaved data by a small triangle, whilst representing the data elements of the group of fast data by small circles. It is further seen in Fig. 2 that 26 data elements have to be classified in these two groups: 16 data elements thereof belong to group 1, whilst the remaining 10 data elements belong to the second group of fast data. It has to be noticed that in an alternative implementation of the present invention, the data elements are already carrying a label similar to the just mentioned labels when entering the modulator MOD in such a way that it is no longer a task of the mapping unit MAP to partition the data elements in groups. *See, e.g.*, Peeters at 6:23-32. As is seen in the second graph two carriers, one of which belongs to subset 1 and the second of which belongs to subset 2, are left unoccupied. Therefore, in step 5, data elements are removed to obtain new constellations without unoccupied carriers. To decide which data elements are removed, the 'required SNR per data element'-tables are consulted. Such a table exists for both subsets of carriers and these tables are stored in 2 table memories similar to the table memories TM1 ... TMN shown in Fig. 1. Such a 'required SNR per data element'-table, as already said in the introduction, is well known in the art. In the present method however, a plurality of these tables is used since each subgroup of carriers has its own table. The two tables corresponding to subset 1 and subset 2 are shown in Fig. 4. Therein, the left table corresponds to subset 1 and the right table corresponds to subset 2. The measured SNR values for each of the carriers f1 ... f11 are listed in the table of Fig. 5. For each carrier, the SNR margin is calculated. These SNR margins are first calculated for each carrier in subset 1 by subtracting the requested SNR from the SNR value measured on each of these carriers. Carrier f1 for example carries 3 data bits in step 4. The SNR measured on f1 equals 22 dB whilst the required SNR allowing f1 to carry 3 data bits is equal to 20 dB. As a result, the SNR margin for f1 equals 2 dB. The SNR margins similarly calculated for f2, f10, f3, f9 and f8 are equal to 0 dB, -1 dB, 7 dB, -1 dB and 2 dB respectively. Since the minimum overall SNR margin equals the overall power decrease that can be performed, data elements are removed from a carrier to an unoccupied carrier in such a way that the minimum SNR margin increases as much as possible. Two carriers, f10 and f9 have an SNR margin of -1 dB. Since 4 data bits are allocated to f10 and 3 data bits are assigned to f9, f10 is more noise sensitive than f9. Therefore, a data bit is removed from f10 to f11. When the same procedure is applied to the second group of fast data elements in Fig. 2, the constellation drawn for step 4 changes into the constellation drawn for step 5.

Claim 10	Peeters Disclosure
	In the sixth step, the data element allocations are equalised within each group. To perform this equalising the signal noise ratio (SNR) measurements, supplied to the processor PROC via its second input I2, are again compared to the required signal noise ratio values stored in the 'required SNR per data element'-tables and applied to the processor PROC via I3. Data elements of the first group are removed from carriers of subset 1 and allocated to other carriers of subset 1 to thereby maximize the minimum SNR margin within this group. The SNR margins for f11, f1, f2, f10, f3, f9 and f8, calculated as already described above, are equal to 1 dB, 2 dB, 0 dB, 2 dB, 7 dB, -1 dB and 2 dB. To increase the minimum SNR margin, a data bit then is removed from the carrier with least SNR margin to the carrier that has the highest SNR margin after this data bit has been added thereto. In the example of Fig. 2, a data bit, previously allocated to f9 is thus removed therefrom and becomes assigned to carrier f3. As a result, the SNR margin of f9 increases from -1 dB to 3 dB, whilst the SNR margin of f3 remains 7 dB. A further data bit, carried by f2, is not removed therefrom to be added to f3 since this would imply a reduction of the SNR margin of f3 to 3 dB without increase of the SNR margin of f2. The same procedure is followed for equalising the fast data elements allocated to the second subset of carriers. When equalising all data elements in the interleaved group and fast group in such a way that the minimum remaining SNR margins for all carriers within each group are maximized, the constellation shown in the graph attached to step 6 in Fig. 2 is obtained. According to the draft ADSL Standard, one bit constellations have to be removed. In step 7 it is therefore checked whether such 1 bit constellations exist or not. If 1 bit constellations are detected, they are upgraded to two bit constellations by removing once more bits from other carriers in a way similar to step 5. It can be seen from the graph attached to step 7 in Fig. 2 that carriers f11 and f5 no longer carry only 1 bit. By removing a first data bit from f2 to f11 and a second data bit from f2 to f3, the SNR margin of f2 is increased from 0 dB to 16 dB. The SNR margin of f11 on the other hand is left unmodified and still equals 1 dB. For each subset of carriers, an optimal data bit allocation is obtained now, i.e. an allocation is found with maximal minimum SNR margins. For subset 1 this minimum SNR margin is equal to 1 dB, for subset 2 the minimum SNR margin equals 3 dB. An overall power decrease of 1 dB can thus be applied if no further steps are performed. *See, e.g.*, Peeters at 6:51-7:34.

Claim 10	Peeters Disclosure
	 Fig. 2  Fig. 3

Claim 10	Peeters Disclosure

Number of bits allocated	Requested SNR (dB)
1	16
2	16
3	20
4	23
5	25

Number of bits allocated	Requested SNR (dB)
1	15
2	15
3	21
4	24
5	27

Fig. 4

Carrier	Measured SNR (dB)
f11	17
f1	22
f2	16
f10	22
f3	23
f9	19
f8	22
f4	23
f7	26
f6	26
f5	18

Fig. 5

See, e.g., Peeters at Figures 2-5.

To the extent TQ Delta alleges that this limitation is not fully disclosed by Peeters, this element would have been obvious to one of ordinary skill in the art based on the state of the art in existence at the time, the explicit and implicit teachings of this reference and the art, the differences between the art and the claimed limitation and the general knowledge of a person of ordinary skill in the art.

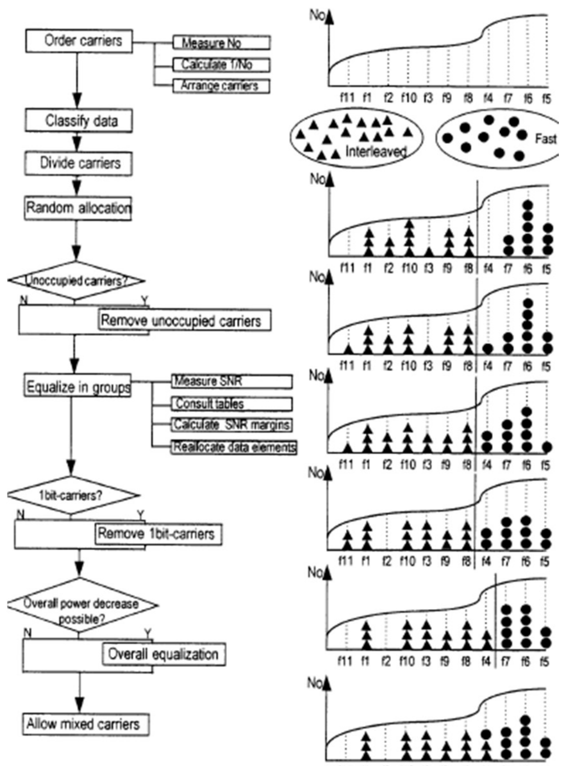
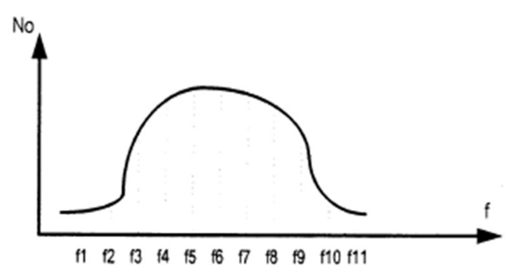
It was well known in the art that the first plurality of carriers to be different than the second plurality of carriers. For example, each of the references in charts F10-354A – F10-354F and F10 Secondary - 354 teach this limitation. It would have been obvious to one of ordinary skill in the art to combine the teachings of Peeters with any of these references, as they all teach systems, apparatuses, or methods related to communication technologies involving multicarrier modulation.

Claim 10	Peeters Disclosure
[10E] wherein the first SNR margin is different than the second SNR margin, and	Under at least TQ Delta's apparent theory of infringement, Peeters discloses and/or renders obvious the first SNR margin is different than the second SNR margin: Such a method and such equipment to perform the method are already known in the art, e.g. from the *US Patent 4,679,227, entitled 'Ensemble modem structure for imperfect transmission media' from the inventor Dirk Hughes-Hartogs*. Therein, a modem is described which transmits and receives digital data on a set of carriers called an ensemble of carrier frequencies. The modem includes a system for variably allocating data elements or data, and power to the carrier frequencies to be transmitted via a telephone line. In a first step, the method performed by this data and power allocating system determines for each carrier frequency the equivalent noise component. Obviously, this is equal to measuring for each carrier frequency the signal noise ratio (SNR) provided that the signal power during this measurement equals 1 power unit. As is described on lines 21-24 of column 11 of the above mentioned US Patent, the equivalent noise components are used in combination with the signal noise ratios necessary for transmission of the data elements with a given maximum bit error rate (BER) to calculate therefrom the required transmission power levels, marginal required power levels for each carrier frequency and data element allocation. As stated on lines 26-27 of column 11 of US Patent 4,679,227, these signal noise ratios necessary for transmission of the data elements are well known in the art, and are found in a table which is called a 'required SNR per data element'-table in the present patent application. The data elements in the known method are then allocated one by one to the carriers requiring the lowest power cost to increase the constellation complexity. In this way, the known method and modem provide a data element allocation to compensate for equivalent noise and to maximize the overall data transmission rate. The known method and modem however treat all data elements in an identical way. In communication networks transporting data elements for different applications and services, the requirements for noise compensation, bit error rate, data transmission rate, bandwidth and so on, may depend on the type of application or service. Several types of data, each of which characterized by its own requirements and specifications, can thus be distinguished. An object of the present invention is to provide a method and equipment of the above known type but which take into account data depending requirements for noise compensation, transmission rate and so on, and wherein data element allocation and transmission for each type of data are thus tuned to its own specifications. According to the invention, this object is achieved in the method, mapping unit and modulator described in claims 1, 13 and 14 respectively. Indeed, in the method described in claim 1, data elements are, according to a predetermined data criterion, e.g. the maximum allowable bit error rate, the required bandwidth, the required data transmission rate, the required compensation for noise, the required compensation for burst errors, ..., or a combination thereof, classified into N groups of data elements. Each group of data elements becomes modulated on a subset of carriers, these carriers being selected out of the full available set of carriers in accordance with another specific criterion, called a predetermined carrier criterion, e.g. the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, ... Based on the relation between data and carrier criteria, the N groups of data elements are linked one by one to the N subsets of carriers. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data.

Claim 10	Peeters Disclosure
	In addition, by using signal noise ratio measurements in combination with information from a 'required SNR per data element'-table, a distribution of data elements requiring the lowest overall power transmission is found in a similar way as described in the earlier cited US Patent, noticing that each group of data elements in the present method is related to its own 'required SNR per data element'-table which renders the allocation method more accurate. A further feature of the present data allocation method is that in a particular first implementation thereof, the predetermined data criterion is equal to service dependent required compensation for occasional noise increase. Telephone service for example will have lower requirements with respect to protection against occasional noise increase than telebanking service wherein all data have to be transmitted faultless. The predetermined carrier criterion in this first implementation is defined as the sensitivity of a carrier for such occasional noise increase. As follows from claims 3 and 4, different sources of such occasional noise increase can be thought off. Burst errors on transmission links in a network for example may damage a sequence of data elements and should thus be seen as a first type of occasional noise increase. A well known technique for compensation of such burst errors is the addition of an error protection code in combination with interleaving of data elements. Such an error protection code adds redundancy at the cost of user data transmission rate whilst interleaving introduces delay effects which enlarge when the depth of interleaving increases. In a particular embodiment of the above mentioned first implementation of the present method, the length of a possibly used error protection code and the complexity of a possibly applied interleaving are minimized by allocating data provided by services with high error compensation requirements to carriers which are least sensitive for these errors. *See, e.g.*, Peeters at 2:6-55. Still a further characteristic feature of the present method is that the occupation of the carriers with data elements is improved by sharing N-1 carriers between two data element groups as is described in claim 8. In the present application, such carriers are called mixed carriers. To assign subsets of carriers to groups of data elements, all carriers are fictively arranged in increasing order or decreasing order of the predetermined carrier criterion (e.g. in increasing order of sensitivity of the carrier for burst errors). A first subset of e.g. 4 carriers is then associated with a first group of data elements, a second subset of e.g. 7 carriers is associated with a second group of data elements having e.g. lower noise compensation requirements than the first group of data elements, and so on. Once having allocated the data elements, the fourth carrier of the first subset however may be partially unoccupied by data elements of the first group and therefore can be used as a mixed carrier, to which also data elements of the second group are allocated. By extrapolation of the above example, it is seen that for N groups of data elements, a maximum amount of N-1 mixed carriers is thus allowed. Still another characteristic feature is that the present data allocation method is dedicated to minimize overall power transmission. This means that, once the allocation is performed, it has become impossible to reduce the overall power transmission by removing a data element from the carrier whereto it is allocated to another carrier. The possibility to reduce the overall power transmission by removing a data element from a carrier to another carrier forming part of the same subset of carriers is eliminated by applying the waterfilling principle described in the already cited US Patent to distribute data elements of a group of data elements to carriers of the associated subset of carriers. In an implementation of this waterfilling principle, data elements can be allocated one by one to the carrier having the largest signal noise ratio margin. This signal noise ratio margin therefor has to be calculated for each carrier by subtracting from the signal noise ratio value measured for this carrier, the required signal noise ratio value to enable allocating data elements thereto. This required signal noise ratio value is found in the 'required SNR per data element'-tables already mentioned. On the other hand, the possibility to reduce overall power transmission by applying another partition into subsets of carriers has to be eliminated. Whenever this possibility exists, the carriers should be redivided into subsets of carriers which are tuned better to the number of data elements in the different groups. Such a situation would occur when a large number of data elements is allocated to a subset of carriers with a small capacity with respect to the 'required SNR per data element'-table specific to this subset, whilst a small number of data elements is allocated to a subset of carriers with a large capacity with respect to the 'required SNR per data element'-table specific to this latter subset. In the latter subset of carriers, the signal noise ratio margins will be large, whilst in the former subset of carriers, signal noise ratio margins will be small.

Claim 10	Peeters Disclosure
	See, e.g., Peeters at 3:14-42. The present invention more specifically relates to the mapping unit MAP and algorithm executed by the processor PROC therein to allocate data elements applied to the first input I1 to the set of 256 carriers. In the following paragraphs, a detailed description of this algorithm and means included in the mapping unit MAP thereto will be given. However, to avoid overloading the figures accompanying the description of the algorithm, the particular situation is chosen wherein 26 data elements have to be allocated to a set of 11 carriers referred to as f1, ..., f11. Obviously, the algorithm to allocate data elements to a set of 256 carriers is not different from the algorithm to allocate data elements to 11 carriers. Extrapolation of the algorithm described in the following paragraphs is thus obvious to a person skilled in the art. The Discrete Multi Tone modulator MOD of the preferred embodiment forms part of a full service network not shown in the drawings. The data elements applied to the first input I1 of the processor PROC thus originate from a plurality of services, each of these services having its own requirements and specifications. Telephone speech data or video data for example are requiring less protection against burst errors than telebanking data. On the other hand, telebanking data may be delayed. Besides, it is well known that a carrier property such as the sensitivity for burst errors is frequency dependent and thus different for each of the above mentioned 256 carriers. From these establishments, it follows that some carriers are more likely to be used for modulation of data generated by a particular service than others. In the first three steps of the allocation method performed by the mapper MAP, carriers and data elements will therefore be arranged in subsets and groups according to their properties and requirements respectively. These groups of data elements and subsets of carriers will then be associated to each other in such a way that data elements become allocated to carriers which are tuned to their specific service dependent requirements. In five additional steps, the data elements of each group are distributed over the carriers of the associated subset in order to obtain a satisfying distribution. *See, e.g.*, Peeters at 5:13-32. The mapper MAP of Fig. 1 for the description in the following paragraphs is supposed to classify the data elements in 2 groups: a group of interleaved data and a group of fast data. The classification is performed based upon the requirements with respect to burst error correction for the data elements as well as to acceptable latency. Indeed, data elements which need to be protected against burst errors will be interleaved and therefore will be allocated to carriers with a high sensitivity for burst errors since for these carriers, protection by interleaving is provided. On the contrary, data such as telephone speech data, which have lower requirements with respect to protection against burst errors but are delay sensitive, will not be interleaved but can be allocated to carriers which are less sensitive for burst errors. *See, e.g.*, Peeters at 5:38-44. As is seen in the second graph two carriers, one of which belongs to subset 1 and the second of which belongs to subset 2, are left unoccupied. Therefore, in step 5, data elements are removed to obtain new constellations without unoccupied carriers. To decide which data elements are removed, the 'required SNR per data element'-tables are consulted. Such a table exists for both subsets of carriers and these tables are stored in 2 table memories similar to the table memories TM1 ... TMN shown in Fig. 1. Such a 'required SNR per data element'-table, as already said in the introduction, is well known in the art. In the present method however, a plurality of these tables is used since each subgroup of carriers has its own table. The two tables corresponding to subset 1 and subset 2 are shown in Fig. 4. Therein, the left table corresponds to subset 1 and the right table corresponds to subset 2. The measured SNR values for each of the carriers f1 ... f11 are listed in the table of Fig. 5. For each carrier, the SNR margin is calculated. These SNR margins

Claim 10	Peeters Disclosure
	are first calculated for each carrier in subset 1 by subtracting the requested SNR from the SNR value measured on each of these carriers. Carrier f1 for example carries 3 data bits in step 4. The SNR measured on f1 equals 22 dB whilst the required SNR allowing f1 to carry 3 data bits is equal to 20 dB. As a result, the SNR margin for f1 equals 2 dB. The SNR margins similarly calculated for f2, f10, f3, f9 and f8 are equal to 0 dB, -1 dB, 7 dB, -1 dB and 2 dB respectively. Since the minimum overall SNR margin equals the overall power decrease that can be performed, data elements are removed from a carrier to an unoccupied carrier in such a way that the minimum SNR margin increases as much as possible. Two carriers, f10 and f9 have an SNR margin of -1 dB. Since 4 data bits are allocated to f10 and 3 data bits are assigned to f9, f10 is more noise sensitive than f9. Therefore, a data bit is removed from f10 to f11. When the same procedure is applied to the second group of fast data elements in Fig. 2, the constellation drawn for step 4 changes into the constellation drawn for step 5. In the sixth step, the data element allocations are equalised within each group. To perform this equalising the signal noise ratio (SNR) measurements, supplied to the processor PROC via its second input I2, are again compared to the required signal noise ratio values stored in the 'required SNR per data element'-tables and applied to the processor PROC via I3. Data elements of the first group are removed from carriers of subset 1 and allocated to other carriers of subset 1 to thereby maximize the minimum SNR margin within this group. The SNR margins for f11, f1, f2, f10, f3, f9 and f8, calculated as already described above, are equal to 1 dB, 2 dB, 0 dB, 2 dB, 7 dB, -1 dB and 2 dB. To increase the minimum SNR margin, a data bit then is removed from the carrier with least SNR margin to the carrier that has the highest SNR margin after this data bit has been added thereto. In the example of Fig. 2, a data bit, previously allocated to f9 is thus removed therefrom and becomes assigned to carrier f3. As a result, the SNR margin of f9 increases from -1 dB to 3 dB, whilst the SNR margin of f3 remains 7 dB. A further data bit, carried by f2, is not removed therefrom to be added to f3 since this would imply a reduction of the SNR margin of f3 to 3 dB without increase of the SNR margin of f2. The same procedure is followed for equalising the fast data elements allocated to the second subset of carriers. When equalising all data elements in the interleaved group and fast group in such a way that the minimum remaining SNR margins for all carriers within each group are maximized, the constellation shown in the graph attached to step 6 in Fig. 2 is obtained. According to the draft ADSL Standard, one bit constellations have to be removed. In step 7 it is therefore checked whether such 1 bit constellations exist or not. If 1 bit constellations are detected, they are upgraded to two bit constellations by removing once more bits from other carriers in a way similar to step 5. It can be seen from the graph attached to step 7 in Fig. 2 that carriers f11 and f5 no longer carry only 1 bit. By removing a first data bit from f2 to f11 and a second data bit from f2 to f3, the SNR margin of f2 is increased from 0 dB to 16 dB. The SNR margin of f11 on the other hand is left unmodified and still equals 1 dB. For each subset of carriers, an optimal data bit allocation is obtained now, i.e. an allocation is found with maximal minimum SNR margins. For subset 1 this minimum SNR margin is equal to 1 dB, for subset 2 the minimum SNR margin equals 3 dB. An overall power decrease of 1 dB can thus be applied if no further steps are performed. *See, e.g.*, Peeters at 6:51-7:34.

Claim 10	Peeters Disclosure
	 Fig. 2  Fig. 3

Claim 10	Peeters Disclosure
	(tables below)

Number of bits allocated	Requested SNR (dB)
1	16
2	16
3	20
4	23
5	25

Number of bits allocated	Requested SNR (dB)
1	15
2	15
3	21
4	24
5	27

Fig. 4

Carrier	Measured SNR (dB)
f11	17
f1	22
f2	16
f10	22
f3	23
f9	19
f8	22
f4	23
f7	26
f6	26
f5	18

Fig. 5

See, e.g., Peeters at Figures 2-5.

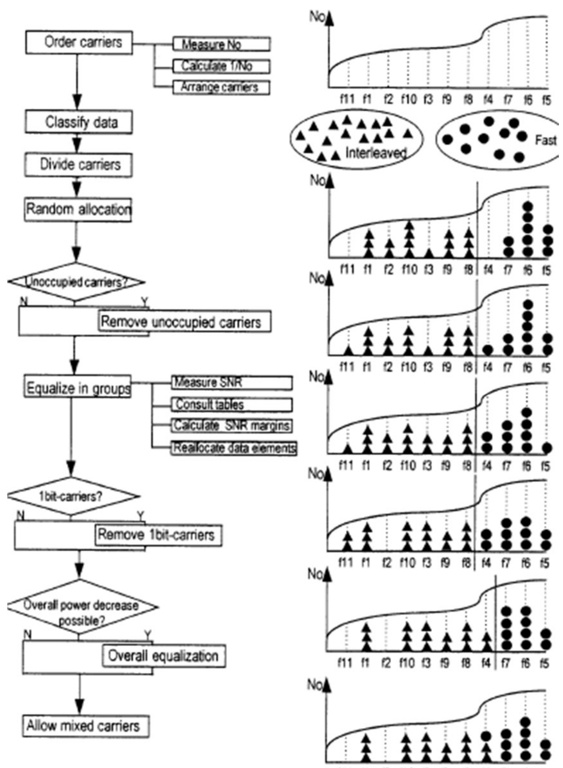
To the extent TQ Delta alleges that this limitation is not fully disclosed by Peeters, this element would have been obvious to one of ordinary skill in the art based on the state of the art in existence at the time, the explicit and implicit teachings of this reference and the art, the differences between the art and the claimed limitation and the general knowledge of a person of ordinary skill in the art.

It was well known in the art that the first SNR margin is different than the second SNR margin. For example, each of the references in charts F10-354A – F10-354F and F10 Secondary - 354 teach this limitation. It would have been obvious to one of ordinary skill in the art to combine the teachings of Peeters with any of these references, as they all teach systems, apparatuses, or methods related to communication technologies involving multicarrier modulation.

Claim 10	Peeters Disclosure
[10F] wherein the first SNR margin provides more robust.	Under at least TQ Delta's apparent theory of infringement, Peeters discloses and/or renders obvious the first SNR margin provides more robust: Such a method and such equipment to perform the method are already known in the art, e.g. from the *US Patent 4,679,227, entitled 'Ensemble modem structure for imperfect transmission media' from the inventor Dirk Hughes-Hartogs*. Therein, a modem is described which transmits and receives digital data on a set of carriers called an ensemble of carrier frequencies. The modem includes a system for variably allocating data elements or data, and power to the carrier frequencies to be transmitted via a telephone line. In a first step, the method performed by this data and power allocating system determines for each carrier frequency the equivalent noise component. Obviously, this is equal to measuring for each carrier frequency the signal noise ratio (SNR) provided that the signal power during this measurement equals 1 power unit. As is described on lines 21-24 of column 11 of the above mentioned US Patent, the equivalent noise components are used in combination with the signal noise ratios necessary for transmission of the data elements with a given maximum bit error rate (BER) to calculate therefrom the required transmission power levels, marginal required power levels for each carrier frequency and data element allocation. As stated on lines 26-27 of column 11 of US Patent 4,679,227, these signal noise ratios necessary for transmission of the data elements are well known in the art, and are found in a table which is called a 'required SNR per data element'-table in the present patent application. The data elements in the known method are then allocated one by one to the carriers requiring the lowest power cost to increase the constellation complexity. In this way, the known method and modem provide a data element allocation to compensate for equivalent noise and to maximize the overall data transmission rate. The known method and modem however treat all data elements in an identical way. In communication networks transporting data elements for different applications and services, the requirements for noise compensation, bit error rate, data transmission rate, bandwidth and so on, may depend on the type of application or service. Several types of data, each of which characterized by its own requirements and specifications, can thus be distinguished. An object of the present invention is to provide a method and equipment of the above known type but which take into account data depending requirements for noise compensation, transmission rate and so on, and wherein data element allocation and transmission for each type of data are thus tuned to its own specifications. According to the invention, this object is achieved in the method, mapping unit and modulator described in claims 1, 13 and 14 respectively. Indeed, in the method described in claim 1, data elements are, according to a predetermined data criterion, e.g. the maximum allowable bit error rate, the required bandwidth, the required data transmission rate, the required compensation for noise, the required compensation for burst errors, ..., or a combination thereof, classified into N groups of data elements. Each group of data elements becomes modulated on a subset of carriers, these carriers being selected out of the full available set of carriers in accordance with another specific criterion, called a predetermined carrier criterion, e.g. the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, ... Based on the relation between data and carrier criteria, the N groups of data elements are linked one by one to the N subsets of carriers. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data.

Claim 10	Peeters Disclosure
	In addition, by using signal noise ratio measurements in combination with information from a 'required SNR per data element'-table, a distribution of data elements requiring the lowest overall power transmission is found in a similar way as described in the earlier cited US Patent, noticing that each group of data elements in the present method is related to its own 'required SNR per data element'-table which renders the allocation method more accurate. A further feature of the present data allocation method is that in a particular first implementation thereof, the predetermined data criterion is equal to service dependent required compensation for occasional noise increase. Telephone service for example will have lower requirements with respect to protection against occasional noise increase than telebanking service wherein all data have to be transmitted faultless. The predetermined carrier criterion in this first implementation is defined as the sensitivity of a carrier for such occasional noise increase. As follows from claims 3 and 4, different sources of such occasional noise increase can be thought off. Burst errors on transmission links in a network for example may damage a sequence of data elements and should thus be seen as a first type of occasional noise increase. A well known technique for compensation of such burst errors is the addition of an error protection code in combination with interleaving of data elements. Such an error protection code adds redundancy at the cost of user data transmission rate whilst interleaving introduces delay effects which enlarge when the depth of interleaving increases. In a particular embodiment of the above mentioned first implementation of the present method, the length of a possibly used error protection code and the complexity of a possibly applied interleaving are minimized by allocating data provided by services with high error compensation requirements to carriers which are least sensitive for these errors. *See, e.g.*, Peeters at 2:6-55. Still a further characteristic feature of the present method is that the occupation of the carriers with data elements is improved by sharing N-1 carriers between two data element groups as is described in claim 8. In the present application, such carriers are called mixed carriers. To assign subsets of carriers to groups of data elements, all carriers are fictively arranged in increasing order or decreasing order of the predetermined carrier criterion (e.g. in increasing order of sensitivity of the carrier for burst errors). A first subset of e.g. 4 carriers is then associated with a first group of data elements, a second subset of e.g. 7 carriers is associated with a second group of data elements having e.g. lower noise compensation requirements than the first group of data elements, and so on. Once having allocated the data elements, the fourth carrier of the first subset however may be partially unoccupied by data elements of the first group and therefore can be used as a mixed carrier, to which also data elements of the second group are allocated. By extrapolation of the above example, it is seen that for N groups of data elements, a maximum amount of N-1 mixed carriers is thus allowed. Still another characteristic feature is that the present data allocation method is dedicated to minimize overall power transmission. This means that, once the allocation is performed, it has become impossible to reduce the overall power transmission by removing a data element from the carrier whereto it is allocated to another carrier. The possibility to reduce the overall power transmission by removing a data element from a carrier to another carrier forming part of the same subset of carriers is eliminated by applying the waterfilling principle described in the already cited US Patent to distribute data elements of a group of data elements to carriers of the associated subset of carriers. In an implementation of this waterfilling principle, data elements can be allocated one by one to the carrier having the largest signal noise ratio margin. This signal noise ratio margin therefor has to be calculated for each carrier by subtracting from the signal noise ratio value measured for this carrier, the required signal noise ratio value to enable allocating data elements thereto. This required signal noise ratio value is found in the 'required SNR per data element'-tables already mentioned. On the other hand, the possibility to reduce overall power transmission by applying another partition into subsets of carriers has to be eliminated. Whenever this possibility exists, the carriers should be redivided into subsets of carriers which are tuned better to the number of data elements in the different groups. Such a situation would occur when a large number of data elements is allocated to a subset of carriers with a small capacity with respect to the 'required SNR per data element'-table specific to this subset, whilst a small number of data elements is allocated to a subset of carriers with a large capacity with respect to the 'required SNR per data element'-table specific to this latter subset. In the latter subset of carriers, the signal noise ratio margins will be large, whilst in the former subset of carriers, signal noise ratio margins will be small.

Claim 10	Peeters Disclosure
	See, e.g., Peeters at 3:14-42. As is seen in the second graph two carriers, one of which belongs to subset 1 and the second of which belongs to subset 2, are left unoccupied. Therefore, in step 5, data elements are removed to obtain new constellations without unoccupied carriers. To decide which data elements are removed, the 'required SNR per data element'-tables are consulted. Such a table exists for both subsets of carriers and these tables are stored in 2 table memories similar to the table memories TM1 ... TMN shown in Fig. 1. Such a 'required SNR per data element'-table, as already said in the introduction, is well known in the art. In the present method however, a plurality of these tables is used since each subgroup of carriers has its own table. The two tables corresponding to subset 1 and subset 2 are shown in Fig. 4. Therein, the left table corresponds to subset 1 and the right table corresponds to subset 2. The measured SNR values for each of the carriers f1 ... f11 are listed in the table of Fig. 5. For each carrier, the SNR margin is calculated. These SNR margins are first calculated for each carrier in subset 1 by subtracting the requested SNR from the SNR value measured on each of these carriers. Carrier f1 for example carries 3 data bits in step 4. The SNR measured on f1 equals 22 dB whilst the required SNR allowing f1 to carry 3 data bits is equal to 20 dB. As a result, the SNR margin for f1 equals 2 dB. The SNR margins similarly calculated for f2, f10, f3, f9 and f8 are equal to 0 dB, -1 dB, 7 dB, -1 dB and 2 dB respectively. Since the minimum overall SNR margin equals the overall power decrease that can be performed, data elements are removed from a carrier to an unoccupied carrier in such a way that the minimum SNR margin increases as much as possible. Two carriers, f10 and f9 have an SNR margin of -1 dB. Since 4 data bits are allocated to f10 and 3 data bits are assigned to f9, f10 is more noise sensitive than f9. Therefore, a data bit is removed from f10 to f11. When the same procedure is applied to the second group of fast data elements in Fig. 2, the constellation drawn for step 4 changes into the constellation drawn for step 5. In the sixth step, the data element allocations are equalised within each group. To perform this equalising the signal noise ratio (SNR) measurements, supplied to the processor PROC via its second input I2, are again compared to the required signal noise ratio values stored in the 'required SNR per data element'-tables and applied to the processor PROC via I3. Data elements of the first group are removed from carriers of subset 1 and allocated to other carriers of subset 1 to thereby maximize the minimum SNR margin within this group. The SNR margins for f11, f1, f2, f10, f3, f9 and f8, calculated as already described above, are equal to 1 dB, 2 dB, 0 dB, 2 dB, 7 dB, -1 dB and 2 dB. To increase the minimum SNR margin, a data bit then is removed from the carrier with least SNR margin to the carrier that has the highest SNR margin after this data bit has been added thereto. In the example of Fig. 2, a data bit, previously allocated to f9 is thus removed therefrom and becomes assigned to carrier f3. As a result, the SNR margin of f9 increases from -1 dB to 3 dB, whilst the SNR margin of f3 remains 7 dB. A further data bit, carried by f2, is not removed therefrom to be added to f3 since this would imply a reduction of the SNR margin of f3 to 3 dB without increase of the SNR margin of f2. The same procedure is followed for equalising the fast data elements allocated to the second subset of carriers. When equalising all data elements in the interleaved group and fast group in such a way that the minimum remaining SNR margins for all carriers within each group are maximized, the constellation shown in the graph attached to step 6 in Fig. 2 is obtained. According to the draft ADSL Standard, one bit constellations have to be removed. In step 7 it is therefore checked whether such 1 bit constellations exist or not. If 1 bit constellations are detected, they are upgraded to two bit constellations by removing once more bits from other carriers in a way similar to step 5. It can be seen from the graph attached to step 7 in Fig. 2 that carriers f11 and f5 no longer carry only 1 bit. By removing a first data bit from f2 to f11 and a second data bit from f2 to f3, the SNR margin of f2 is increased from 0 dB to 16 dB. The SNR margin of f11 on the other hand is left unmodified and still equals 1 dB. For each subset of carriers, an optimal data bit allocation is obtained now, i.e. an allocation is found with maximal minimum SNR margins. For subset 1 this minimum SNR margin is equal to 1 dB, for subset 2 the minimum SNR margin equals 3 dB. An overall power decrease of 1 dB can thus be applied if no further steps are performed.

Claim 10	Peeters Disclosure
	See, e.g., Peeters at 6:51-7:34.  Fig. 2

Claim 10	Peeters Disclosure

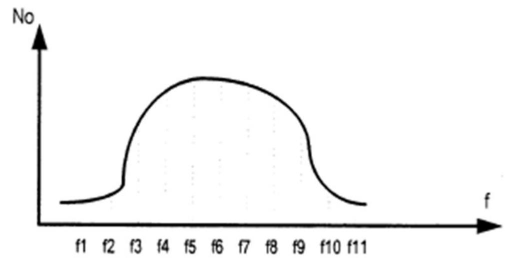


Fig. 3

Number of bits allocated	Requested SNR (dB)
1	16
2	16
3	20
4	23
5	25

Number of bits allocated	Requested SNR (dB)
1	15
2	15
3	21
4	24
5	27

Fig. 4

Carrier	Measured SNR (dB)
f11	17
f1	22
f2	16
f10	22
f3	23
f9	19
f8	22
f4	23
f7	26
f6	26
f5	18

Fig. 5

See, e.g., Peeters at Figures 2-5.

To the extent TQ Delta alleges that this limitation is not fully disclosed by Peeters, this element would have been obvious to one of ordinary skill in the art based on the state of the art in existence at the time, the explicit and implicit teachings of this reference and the art, the

Claim 10	Peeters Disclosure
	differences between the art and the claimed limitation and the general knowledge of a person of ordinary skill in the art. It was well known in the art that the first SNR margin provides more robust. For example, each of the references in charts F10-354A – F10-354F and F10 Secondary - 354 teach this limitation. It would have been obvious to one of ordinary skill in the art to combine the teachings of Peeters with any of these references, as they all teach systems, apparatuses, or methods related to communication technologies involving multicarrier modulation.

Claim 11	Peeters Disclosure
[11] The transceiver of claim 10, wherein the first SNR margin specifies a first value for an increase in noise associated with the first plurality of carriers.	Under at least TQ Delta's apparent theory of infringement, Peeters discloses and/or renders obvious the first SNR margin specifies a first value for an increase in noise associated with the first plurality of carriers: Such a method and such equipment to perform the method are already known in the art, e.g. from the *US Patent 4,679,227, entitled 'Ensemble modem structure for imperfect transmission media' from the inventor Dirk Hughes-Hartogs*. Therein, a modem is described which transmits and receives digital data on a set of carriers called an ensemble of carrier frequencies. The modem includes a system for variably allocating data elements or data, and power to the carrier frequencies to be transmitted via a telephone line. In a first step, the method performed by this data and power allocating system determines for each carrier frequency the equivalent noise component. Obviously, this is equal to measuring for each carrier frequency the signal noise ratio (SNR) provided that the signal power during this measurement equals 1 power unit. As is described on lines 21-24 of column 11 of the above mentioned US Patent, the equivalent noise components are used in combination with the signal noise ratios necessary for transmission of the data elements with a given maximum bit error rate (BER) to calculate therefrom the required transmission power levels, marginal required power levels for each carrier frequency and data element allocation. As stated on lines 26-27 of column 11 of US Patent 4,679,227, these signal noise ratios necessary for transmission of the data elements are well known in the art, and are found in a table which is called a 'required SNR per data element'-table in the present patent application. The data elements in the known method are then allocated one by one to the carriers requiring the lowest power cost to increase the constellation complexity. In this way, the known method and modem provide a data element allocation to compensate for equivalent noise and to maximize the overall data transmission rate. The known method and modem however treat all data elements in an identical way. In communication networks transporting data elements for different applications and services, the requirements for noise compensation, bit error rate, data transmission rate, bandwidth and so on, may depend on the type of application or service. Several types of data, each of which characterized by its own requirements and specifications, can thus be distinguished.

Claim 11	Peeters Disclosure
	An object of the present invention is to provide a method and equipment of the above known type but which take into account data depending requirements for noise compensation, transmission rate and so on, and wherein data element allocation and transmission for each type of data are thus tuned to its own specifications. According to the invention, this object is achieved in the method, mapping unit and modulator described in claims 1, 13 and 14 respectively. Indeed, in the method described in claim 1, data elements are, according to a predetermined data criterion, e.g. the maximum allowable bit error rate, the required bandwidth, the required data transmission rate, the required compensation for noise, the required compensation for burst errors, ..., or a combination thereof, classified into N groups of data elements. Each group of data elements becomes modulated on a subset of carriers, these carriers being selected out of the full available set of carriers in accordance with another specific criterion, called a predetermined carrier criterion, e.g. the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, ... Based on the relation between data and carrier criteria, the N groups of data elements are linked one by one to the N subsets of carriers. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data. In addition, by using signal noise ratio measurements in combination with information from a 'required SNR per data element'-table, a distribution of data elements requiring the lowest overall power transmission is found in a similar way as described in the earlier cited US Patent, noticing that each group of data elements in the present method is related to its own 'required SNR per data element'-table which renders the allocation method more accurate. A further feature of the present data allocation method is that in a particular first implementation thereof, the predetermined data criterion is equal to service dependent required compensation for occasional noise increase. Telephone service for example will have lower requirements with respect to protection against occasional noise increase than telebanking service wherein all data have to be transmitted faultless. The predetermined carrier criterion in this first implementation is defined as the sensitivity of a carrier for such occasional noise increase. As follows from claims 3 and 4, different sources of such occasional noise increase can be thought off. Burst errors on transmission links in a network for example may damage a sequence of data elements and should thus be seen as a first type of occasional noise increase. A well known technique for compensation of such burst errors is the addition of an error protection code in combination with interleaving of data elements. Such an error protection code adds redundancy at the cost of user data transmission rate whilst interleaving introduces delay effects which enlarge when the depth of interleaving increases. In a particular embodiment of the above mentioned first implementation of the present method, the length of a possibly used error protection code and the complexity of a possibly applied interleaving are minimized by allocating data provided by services with high error compensation requirements to carriers which are least sensitive for these errors. *See, e.g.*, Peeters at 2:6-55. Another characteristic feature of the present method, described in claim 5, is that in a particular embodiment of the first implementation, the sensitivity for occasional noise increase of a carrier is estimated by measuring the noise power No on this carrier and inverting the measured result. Indeed, as will be proven later on in the description, 1/No is equal to the variation of the carrier's signal noise ratio (SNRdB) in decibels at variation of the noise power on this carrier. This variation of the signal noise ratio obviously is a measure for the sensitivity of the carrier. Yet another feature of the present method, described in claim 6, is that in an alternative embodiment of the first implementation, the sensitivity for occasional noise increase of a carrier is estimated by calculating the variation of the bit error rate (BER) of this carrier at variation of the noise power on this carrier. Indeed, the variation of the bit error rate (BER) obviously is also a measure for the sensitivity of the carrier. *See, e.g.*, Peeters at 3:1-9.

Claim 11	Peeters Disclosure
	As is seen in the second graph two carriers, one of which belongs to subset 1 and the second of which belongs to subset 2, are left unoccupied. Therefore, in step 5, data elements are removed to obtain new constellations without unoccupied carriers. To decide which data elements are removed, the 'required SNR per data element'-tables are consulted. Such a table exists for both subsets of carriers and these tables are stored in 2 table memories similar to the table memories TM1 ... TMN shown in Fig. 1. Such a 'required SNR per data element'-table, as already said in the introduction, is well known in the art. In the present method however, a plurality of these tables is used since each subgroup of carriers has its own table. The two tables corresponding to subset 1 and subset 2 are shown in Fig. 4. Therein, the left table corresponds to subset 1 and the right table corresponds to subset 2. The measured SNR values for each of the carriers f1 ... f11 are listed in the table of Fig. 5. For each carrier, the SNR margin is calculated. These SNR margins are first calculated for each carrier in subset 1 by subtracting the requested SNR from the SNR value measured on each of these carriers. Carrier f1 for example carries 3 data bits in step 4. The SNR measured on f1 equals 22 dB whilst the required SNR allowing f1 to carry 3 data bits is equal to 20 dB. As a result, the SNR margin for f1 equals 2 dB. The SNR margins similarly calculated for f2, f10, f3, f9 and f8 are equal to 0 dB, -1 dB, 7 dB, -1 dB and 2 dB respectively. Since the minimum overall SNR margin equals the overall power decrease that can be performed, data elements are removed from a carrier to an unoccupied carrier in such a way that the minimum SNR margin increases as much as possible. Two carriers, f10 and f9 have an SNR margin of -1 dB. Since 4 data bits are allocated to f10 and 3 data bits are assigned to f9, f10 is more noise sensitive than f9. Therefore, a data bit is removed from f10 to f11. When the same procedure is applied to the second group of fast data elements in Fig. 2, the constellation drawn for step 4 changes into the constellation drawn for step 5. In the sixth step, the data element allocations are equalised within each group. To perform this equalising the signal noise ratio (SNR) measurements, supplied to the processor PROC via its second input I2, are again compared to the required signal noise ratio values stored in the 'required SNR per data element'-tables and applied to the processor PROC via I3. Data elements of the first group are removed from carriers of subset 1 and allocated to other carriers of subset 1 to thereby maximize the minimum SNR margin within this group. The SNR margins for f11, f1, f2, f10, f3, f9 and f8, calculated as already described above, are equal to 1 dB, 2 dB, 0 dB, 2 dB, 7 dB, -1 dB and 2 dB. To increase the minimum SNR margin, a data bit then is removed from the carrier with least SNR margin to the carrier that has the highest SNR margin after this data bit has been added thereto. In the example of Fig. 2, a data bit, previously allocated to f9 is thus removed therefrom and becomes assigned to carrier f3. As a result, the SNR margin of f9 increases from -1 dB to 3 dB, whilst the SNR margin of f3 remains 7 dB. A further data bit, carried by f2, is not removed therefrom to be added to f3 since this would imply a reduction of the SNR margin of f3 to 3 dB without increase of the SNR margin of f2. The same procedure is followed for equalising the fast data elements allocated to the second subset of carriers. When equalising all data elements in the interleaved group and fast group in such a way that the minimum remaining SNR margins for all carriers within each group are maximized, the constellation shown in the graph attached to step 6 in Fig. 2 is obtained. According to the draft ADSL Standard, one bit constellations have to be removed. In step 7 it is therefore checked whether such 1 bit constellations exist or not. If 1 bit constellations are detected, they are upgraded to two bit constellations by removing once more bits from other carriers in a way similar to step 5. It can be seen from the graph attached to step 7 in Fig. 2 that carriers f11 and f5 no longer carry only 1 bit. By removing a first data bit from f2 to f11 and a second data bit from f2 to f3, the SNR margin of f2 is increased from 0 dB to 16 dB. The SNR margin of f11 on the other hand is left unmodified and still equals 1 dB. For each subset of carriers, an optimal data bit allocation is obtained now, i.e. an allocation is found with maximal minimum SNR margins. For subset 1 this minimum SNR margin is equal to 1 dB, for subset 2 the minimum SNR margin equals 3 dB. An overall power decrease of 1 dB can thus be applied if no further steps are performed. *See, e.g.*, Peeters at 6:51-7:34.

Claim 11	Peeters Disclosure
	To the extent TQ Delta alleges that this limitation is not fully disclosed by Peeters, this element would have been obvious to one of ordinary skill in the art based on the state of the art in existence at the time, the explicit and implicit teachings of this reference and the art, the differences between the art and the claimed limitation and the general knowledge of a person of ordinary skill in the art. It was well known in the art that the first SNR margin specifies a first value for an increase in noise associated with the first plurality of carriers. For example, each of the references in charts F10-354A – F10-354F and F10 Secondary - 354 teach this limitation. It would have been obvious to one of ordinary skill in the art to combine the teachings of Peeters with any of these references, as they all teach systems, apparatuses, or methods related to communication technologies involving multicarrier modulation.

Claim 12	Peeters Disclosure
[12] The transceiver of claim 10, wherein the second SNR margin specifies a second value for an increase in noise associated with the second plurality of carriers.	Under at least TQ Delta's apparent theory of infringement, Peeters discloses and/or renders obvious the second SNR margin specifies a second value for an increase in noise associated with the second plurality of carriers:

Claim 12	Peeters Disclosure
	Such a method and such equipment to perform the method are already known in the art, e.g. from the *US Patent 4,679,227, entitled 'Ensemble modem structure for imperfect transmission media' from the inventor Dirk Hughes-Hartogs*. Therein, a modem is described which transmits and receives digital data on a set of carriers called an ensemble of carrier frequencies. The modem includes a system for variably allocating data elements or data, and power to the carrier frequencies to be transmitted via a telephone line. In a first step, the method performed by this data and power allocating system determines for each carrier frequency the equivalent noise component. Obviously, this is equal to measuring for each carrier frequency the signal noise ratio (SNR) provided that the signal power during this measurement equals 1 power unit. As is described on lines 21-24 of column 11 of the above mentioned US Patent, the equivalent noise components are used in combination with the signal noise ratios necessary for transmission of the data elements with a given maximum bit error rate (BER) to calculate therefrom the required transmission power levels, marginal required power levels for each carrier frequency and data element allocation. As stated on lines 26-27 of column 11 of US Patent 4,679,227, these signal noise ratios necessary for transmission of the data elements are well known in the art, and are found in a table which is called a 'required SNR per data element'-table in the present patent application. The data elements in the known method are then allocated one by one to the carriers requiring the lowest power cost to increase the constellation complexity. In this way, the known method and modem provide a data element allocation to compensate for equivalent noise and to maximize the overall data transmission rate. The known method and modem however treat all data elements in an identical way. In communication networks transporting data elements for different applications and services, the requirements for noise compensation, bit error rate, data transmission rate, bandwidth and so on, may depend on the type of application or service. Several types of data, each of which characterized by its own requirements and specifications, can thus be distinguished. An object of the present invention is to provide a method and equipment of the above known type but which take into account data depending requirements for noise compensation, transmission rate and so on, and wherein data element allocation and transmission for each type of data are thus tuned to its own specifications. According to the invention, this object is achieved in the method, mapping unit and modulator described in claims 1, 13 and 14 respectively. Indeed, in the method described in claim 1, data elements are, according to a predetermined data criterion, e.g. the maximum allowable bit error rate, the required bandwidth, the required data transmission rate, the required compensation for noise, the required compensation for burst errors, ..., or a combination thereof, classified into N groups of data elements. Each group of data elements becomes modulated on a subset of carriers, these carriers being selected out of the full available set of carriers in accordance with another specific criterion, called a predetermined carrier criterion, e.g. the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, ... Based on the relation between data and carrier criteria, the N groups of data elements are linked one by one to the N subsets of carriers. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data.

Claim 12	Peeters Disclosure
	In addition, by using signal noise ratio measurements in combination with information from a 'required SNR per data element'-table, a distribution of data elements requiring the lowest overall power transmission is found in a similar way as described in the earlier cited US Patent, noticing that each group of data elements in the present method is related to its own 'required SNR per data element'-table which renders the allocation method more accurate. A further feature of the present data allocation method is that in a particular first implementation thereof, the predetermined data criterion is equal to service dependent required compensation for occasional noise increase. Telephone service for example will have lower requirements with respect to protection against occasional noise increase than telebanking service wherein all data have to be transmitted faultless. The predetermined carrier criterion in this first implementation is defined as the sensitivity of a carrier for such occasional noise increase. As follows from claims 3 and 4, different sources of such occasional noise increase can be thought off. Burst errors on transmission links in a network for example may damage a sequence of data elements and should thus be seen as a first type of occasional noise increase. A well known technique for compensation of such burst errors is the addition of an error protection code in combination with interleaving of data elements. Such an error protection code adds redundancy at the cost of user data transmission rate whilst interleaving introduces delay effects which enlarge when the depth of interleaving increases. In a particular embodiment of the above mentioned first implementation of the present method, the length of a possibly used error protection code and the complexity of a possibly applied interleaving are minimized by allocating data provided by services with high error compensation requirements to carriers which are least sensitive for these errors. *See, e.g.*, Peeters at 2:6-55. Another characteristic feature of the present method, described in claim 5, is that in a particular embodiment of the first implementation, the sensitivity for occasional noise increase of a carrier is estimated by measuring the noise power No on this carrier and inverting the measured result. Indeed, as will be proven later on in the description, 1/No is equal to the variation of the carrier's signal noise ratio (SNRdB) in decibels at variation of the noise power on this carrier. This variation of the signal noise ratio obviously is a measure for the sensitivity of the carrier. Yet another feature of the present method, described in claim 6, is that in an alternative embodiment of the first implementation, the sensitivity for occasional noise increase of a carrier is estimated by calculating the variation of the bit error rate (BER) of this carrier at variation of the noise power on this carrier. Indeed, the variation of the bit error rate (BER) obviously is also a measure for the sensitivity of the carrier. *See, e.g.*, Peeters at 3:1-9. As is seen in the second graph two carriers, one of which belongs to subset 1 and the second of which belongs to subset 2, are left unoccupied. Therefore, in step 5, data elements are removed to obtain new constellations without unoccupied carriers. To decide which data elements are removed, the 'required SNR per data element'-tables are consulted. Such a table exists for both subsets of carriers and these tables are stored in 2 table memories similar to the table memories TM1 ... TMN shown in Fig. 1. Such a 'required SNR per data element'-table, as already said in the introduction, is well known in the art. In the present method however, a plurality of these tables is used since each subgroup of carriers has its own table. The two tables corresponding to subset 1 and subset 2 are shown in Fig. 4. Therein, the left table corresponds to subset 1 and the right table corresponds to subset 2. The measured SNR values for each of the carriers f1 ... f11 are listed in the table of Fig. 5. For each carrier, the SNR margin is calculated. These SNR margins

Claim 12	Peeters Disclosure
	are first calculated for each carrier in subset 1 by subtracting the requested SNR from the SNR value measured on each of these carriers. Carrier f1 for example carries 3 data bits in step 4. The SNR measured on f1 equals 22 dB whilst the required SNR allowing f1 to carry 3 data bits is equal to 20 dB. As a result, the SNR margin for f1 equals 2 dB. The SNR margins similarly calculated for f2, f10, f3, f9 and f8 are equal to 0 dB, -1 dB, 7 dB, -1 dB and 2 dB respectively. Since the minimum overall SNR margin equals the overall power decrease that can be performed, data elements are removed from a carrier to an unoccupied carrier in such a way that the minimum SNR margin increases as much as possible. Two carriers, f10 and f9 have an SNR margin of -1 dB. Since 4 data bits are allocated to f10 and 3 data bits are assigned to f9, f10 is more noise sensitive than f9. Therefore, a data bit is removed from f10 to f11. When the same procedure is applied to the second group of fast data elements in Fig. 2, the constellation drawn for step 4 changes into the constellation drawn for step 5. In the sixth step, the data element allocations are equalised within each group. To perform this equalising the signal noise ratio (SNR) measurements, supplied to the processor PROC via its second input I2, are again compared to the required signal noise ratio values stored in the 'required SNR per data element'-tables and applied to the processor PROC via I3. Data elements of the first group are removed from carriers of subset 1 and allocated to other carriers of subset 1 to thereby maximize the minimum SNR margin within this group. The SNR margins for f11, f1, f2, f10, f3, f9 and f8, calculated as already described above, are equal to 1 dB, 2 dB, 0 dB, 2 dB, 7 dB, -1 dB and 2 dB. To increase the minimum SNR margin, a data bit then is removed from the carrier with least SNR margin to the carrier that has the highest SNR margin after this data bit has been added thereto. In the example of Fig. 2, a data bit, previously allocated to f9 is thus removed therefrom and becomes assigned to carrier f3. As a result, the SNR margin of f9 increases from -1 dB to 3 dB, whilst the SNR margin of f3 remains 7 dB. A further data bit, carried by f2, is not removed therefrom to be added to f3 since this would imply a reduction of the SNR margin of f3 to 3 dB without increase of the SNR margin of f2. The same procedure is followed for equalising the fast data elements allocated to the second subset of carriers. When equalising all data elements in the interleaved group and fast group in such a way that the minimum remaining SNR margins for all carriers within each group are maximized, the constellation shown in the graph attached to step 6 in Fig. 2 is obtained. According to the draft ADSL Standard, one bit constellations have to be removed. In step 7 it is therefore checked whether such 1 bit constellations exist or not. If 1 bit constellations are detected, they are upgraded to two bit constellations by removing once more bits from other carriers in a way similar to step 5. It can be seen from the graph attached to step 7 in Fig. 2 that carriers f11 and f5 no longer carry only 1 bit. By removing a first data bit from f2 to f11 and a second data bit from f2 to f3, the SNR margin of f2 is increased from 0 dB to 16 dB. The SNR margin of f11 on the other hand is left unmodified and still equals 1 dB. For each subset of carriers, an optimal data bit allocation is obtained now, i.e. an allocation is found with maximal minimum SNR margins. For subset 1 this minimum SNR margin is equal to 1 dB, for subset 2 the minimum SNR margin equals 3 dB. An overall power decrease of 1 dB can thus be applied if no further steps are performed. *See, e.g.*, Peeters at 6:51-7:34. To the extent TQ Delta alleges that this limitation is not fully disclosed by Peeters, this element would have been obvious to one of ordinary skill in the art based on the state of the art in existence at the time, the explicit and implicit teachings of this reference and the art, the differences between the art and the claimed limitation and the general knowledge of a person of ordinary skill in the art.

Claim 12	Peeters Disclosure
	It was well known in the art that the second SNR margin specifies a second value for an increase in noise associated with the second plurality of carriers. For example, each of the references in charts F10-354A – F10-354F and F10 Secondary - 354 teach this limitation. It would have been obvious to one of ordinary skill in the art to combine the teachings of Peeters with any of these references, as they all teach systems, apparatuses, or methods related to communication technologies involving multicarrier modulation.